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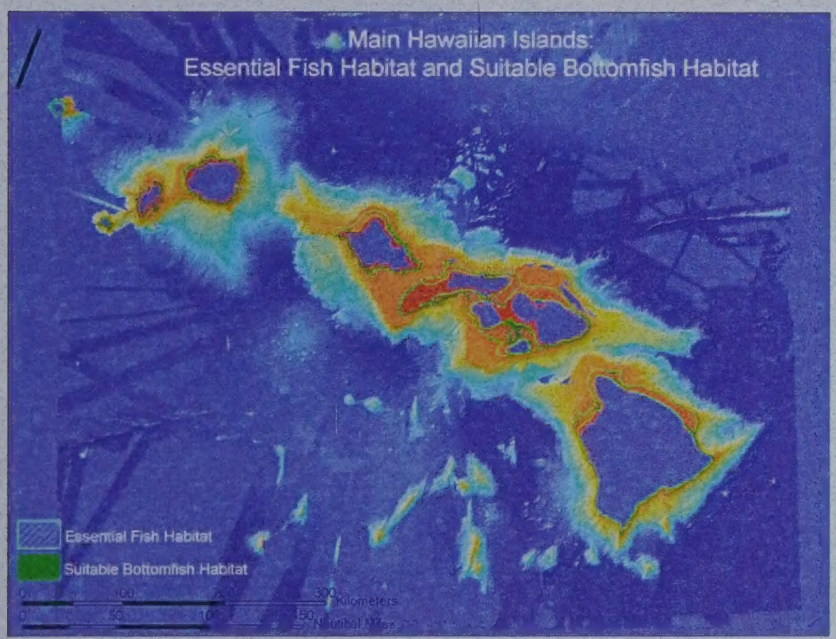
Linking Hawaii Fisherman Reported Commercial Bottomfish Catch Data to Potential Bottomfish Habitat and Proposed Restricted Fishing Areas using GIS and Spatial Analysis



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National Oceanic and Atmospheric Administration
U.S. Department of Commerce

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Linking Hawaii Fisherman Reported Commercial Bottomfish Catch Data to Potential Bottomfish Habitat and Proposed Restricted Fishing Areas using GIS and Spatial Analysis

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EXECUTIVE SUMMARY

This report outlines an effort to spatially link commercial bottomfish catch data from the State of Hawaii Fisherman Reporting System with potential adult bottomfish habitat and restricted fishing areas as proposed by the State of Hawaii (SOH) and the Western Pacific Fishery Management Council (WPFMC). In carrying out the analysis, data limitations required that we make multiple assumptions about "suitable" bottomfish habitat and the accuracy of reported catch locations. The results of the analysis are displayed in a series of maps and tables that provide a picture of the current commercial bottomfish fishing areas relative to suitable habitat and the possible relationships among habitat, reported catch, and Bottomfish Restricted Fishing Areas (BRFAs).

This analysis was finished prior to action taken by the State of Hawaii to officially adopt new BRFA boundaries. Since the State has legally implemented the new boundaries, all references in this paper to "proposed BRFAs" should be understood to refer to the new BRFAs. All references in this paper to "existing BRFAs" should be understood to refer to the previous implementation of 19 original BRFAs that have since been replaced by the 12 newly adopted BRFAs.

INTRODUCTION

The Hawaiian Islands bottomfish fishery typically targets a range of snappers and groupers that live between the depths of 100 and 400 meters, These and other deep-water snappers have been found to be associated with certain benthic features, such as high-relief hard-bottom slopes (Kelley, et al., 2006; Kelley and Ikehara, 2006; Kelley, 2000; and Yoklavich, et al., 2000). In 1998, following an assessment by the National Marine Fisheries Service that stocks of ehu and onaga were approaching a low "Spawning Potential Ratio" in the main Hawaiian Islands (MHI) (State of Hawaii, 2006), the State of Hawaii Department of Land and Natural Resources (DLNR) implemented Bottomfish Restricted Fishing Areas (BRFAs). The 19 BRFAs were an attempt by the State to eliminate fishing in certain geographic areas that might be high-quality bottomfish habitat to help ensure long-term sustainability of bottomfish stocks (State of Hawaii, 2006). Despite the implementation of the 19 BRFAs, in 2005, the Pacific Islands Fisheries Science Center determined that "overfishing" of bottomfish was occurring in the main Hawaiian Islands, and action was needed to reduce bottomfish fishing mortality by at least 24% (Moffitt, et al., 2006). In response, the DLNR proposed to redesign their system of BRFAs, reducing the overall number to 12, but increasing the size and quality of the areas closed to bottomfishing. The Western Pacific Fishery Management Council (WPFMC) also proposed two potential areas for closure; Penguin Bank and Middle Bank. In the remainder of this report, the general term Restricted Fishing Area (RFA) is used to refer to such management areas designated by the DLNR or WPFMC.

This analysis attempts to quantify the amount of high-quality bottomfish habitat within the proposed RFAs, to link reported bottomfish catch data with the favorable habitats within the proposed RFAs, and to provide a metric of potential fishing mortality reduction by assuming a direct relationship between favorable habitat and bottomfish catch.

Habitat Delineation

Delineation of potential habitat for commercial bottomfish was the first task. Fortunately, an almost complete set of multibeam and sidescan sonar data has been collected in the MHI over the last decade by the Pacific Islands Benthic Habitat Mapping Group, the University of Hawaii Undersea Research Laboratory (HURL), and the Hawaii Mapping Research Group. These data, most of which are in the public domain, include bathymetry and backscatter values for the areas of interest around the main Hawaiian Islands. These data were gridded into 20-m grid cells. Slope was derived as a first derivative of bathymetry values. Substrate hardness was derived from a selected set of backscatter values, with those areas falling outside a particular range of backscatter values being classified as nonhard.

The criteria used to delineate possible bottomfish habitats were depth, slope and hardness. The depth range chosen to be most appropriate for this analysis was 100 to 400 m, a modified definition of essential fish habitat (EFH) as defined for this species complex. Next, slopes greater than 20^{o} were selected to further delimit the modified EFH areas into areas more likely to harbor targetable bottomfish. Then, areas that met a particular range of backscatter values (the particular values depend on the instrument used in the survey) were designated as hard bottom. Using geographic information system (GIS) software, digital maps of the main Hawaiian Islands were created that met each of these criteria. The areas in these three map products that intersected with each other, and thus met all three limiting criteria, were deemed to be "suitable" adult bottomfish habitat (see Figures 1 and 1a for a graphical example). Table 1 provides a measure of modified EFH, slope, hardness, and suitable habitat for each island area (the Maui numbers include Penguin Bank, Molokai, Kahoolawe, and Lanai). Table 1(a) provides a summary of (1) total modified EFH area; (2) total hard bottom area within the modified EFH; (3) total suitable habitat within the modified EFH; (4) total suitable habitat within the current State of Hawaii RFAs; (5) total suitable habitat within the proposed State of Hawaii RFAs; (6) total suitable habitat within the proposed WPFMC RFAs; (7) and the total suitable habitat within the combined proposed State and WPFMC RFAs.

We acknowledge that commercial bottomfish, especially uku, are found and extracted in other areas besides those that meet these selection criteria. However, submersible observations and fishing efforts by Dr. Chris Kelley, of HURL, indicate that these criteria are reasonable indicators of the presence of the species of interest for this analysis, and they correlate well with commercial fishing efforts (C. Kelley, pers. comm.). We are also cognizant that these habitats do not consider any life stages other than adult. Finally, we know that even some habitats that meet all of these selection criteria may still not be favorable due to a lack of adequate rugosity. For purposes of this analysis, we have assumed that the commercial bottomfish of interest prefer these designated habitats and that the commercially reported catch is taken predominately from such habitats, but this is ultimately a researchable hypothesis.

Fisherman Reported Catch Data and State Commercial Fisheries Statistical Reporting Zones

The State of Hawaii commercial fisherman catch reporting system provides self-reported catch data from commercial bottomfishers operating in the Hawaiian Islands. Although the report forms used in this system have a number of fields that would provide very useful information for analysts and managers, few of the fields are typically filled out. The fields that are typically populated include license number, date, reporting area, gear, hours fished, vessel name, and number and pounds of fish caught. There is quite a bit of discussion regarding the accuracy of the reporting. For this analysis, I assumed that the fishermen reported their catch, species, and reporting zone accurately, although it is often difficult for a fisherman to precisely know in which reporting zone he is actually fishing because of the lack of definition and consistency in the reporting zone maps. Catch data were summed by species and zone.

State of Hawaii commercial fisheries statistical reporting zones used in this report are a modification of the digital reporting zones file that had been supplied by the Division of Aquatic Resources for use in a previous research project. This digital version of the paper charts showed errors and inconsistencies, and did not lend itself to meaningful analysis of the catch data. After consulting with the original mapmaker, and after receiving feedback on the common use of the charts, we modified the reporting zone charts to normalize the inshore reporting zones and create a consistent two-mile seaward boundary. Offshore zone boundaries were altered to align with inshore extents of the proposed areas. All other zones were unchanged. Having reporting zones with well-defined boundaries coincide with important habitat features (such as the 100-m contours) will enable future spatial analyses of bottomfish catch relative to habitat to provide better insight into the impacts of RFAs. In addition, catch reporting by latitude and longitude of sets would best facilitate a precise spatial analysis, but only if positions were accurately and precisely reported.

Habitat and Catch Analysis by Reporting Zone

Using GIS, delineated habitat areas were spatially joined to the modified reporting zones (see Figs. 2–5) to provide a metric of habitat area in each zone. Figure 6 provides a graphic of the percentage of each reporting zone that has potentially suitable habitat.

Commercial catch data were then spatially joined to the modified reporting zones to provide a graphic representation of the number of pounds of fish reported taken from each zone. Figures 7–11 display the 2005 reported catch in pounds in each zone for five important snappers: onaga (*Etelis coruscans*), opakapaka (*Pristipomoides filamentosus*), ehu (*Etelis carbunculus*), uku (*Aprion virescens*), and gindai (*Pristipomoides zonatus*), respectively.

Restricted Fishing Areas (RFAs)

The RFAs proposed by the State of Hawaii (SOH) and the WPFMC were digitally mapped and spatially intersected with maps of the modified EFH, slope, hardness, and suitable habitat to derive the area of suitable habitat contained within the RFAs as grouped by island area and Middle Bank. Tables 3 and 4 provide the areas in square kilometers of EFH, 20° slope, hard bottom, and suitable habitat for the existing RFAs and the proposed State RFAs by island (in this analysis, Penguin Bank, Molokai, Lanai, and Kahoolawe were considered part of Maui). Tables 5 and 6 provide the areas in square kilometers of EFH, 20° slope, hard bottom, and suitable habitat for proposed WPRMC RFAs and combined State of Hawaii and WPFMC RFAs. Table 7 provides numbers in square kilometers for EFH, slope, hardness, and suitable habitat divided into those RFA areas that fall within three miles of shore and those that are outside of the state three-mile limit.

Allocation of Catch to Restricted Fishing Areas

In an attempt to allocate reported catch to the proposed RFAs, catch was assumed to be directly correlated with amount of suitable habitat in each reporting zone. Suitable habitat areas in each zone were then spatially selected using the proposed RFA boundaries. This process allowed us to derive a percentage of habitat area, by reporting zone, within each RFA. Catch data in each zone were then multiplied by the percentage of that zone's habitat contained within the RFA.

For example, the Penguin Bank coincident reporting zones contain ~ 15.4 km^2 of suitable habitat. The proposed State of Hawaii RFA for Penguin Bank includes ~ 8.7 km^2 of suitable habitat. Therefore, the combined catch from reporting zones 331 and 328 was multiplied by 0.563 (the ratio 7 km/15.4 km) to estimate the catch that occurs within the proposed RFA.

The results of this analysis are presented in Figures 12–23 as both catch in pounds in each RFA by reporting zone and percentage of the total catch by reporting zone occurring within the respective RFAs. Tables 8, 9, and 10 provide estimates of the catch in pounds of onaga, opakapaka, and ehu within proposed RFAs based on habitat percentages, catch within the reporting zone and coincident zones (if the RFA spanned more than 1 zone), and catch within zones surrounding entire island areas and banks.

Table 1. Area (km^2) of modified EFH, hard substrate, 20° slope, and suitable habitat within each island area.

Island Area	Modified EFH (100–400 m depth)		Hard Substrate		Slopes > 20 Degrees		Suitable Habitat	
	km^2	% of total	km^2	% of total	km^2	% of total	km^2	% of total
Middle Bank	85.1	1.5	39.1	3.7	12.1	2.7	7.5	3.1
Kaula Rock	28.9	0.5	10.7	1.0	19.7	4.4	7.5	3.1
Niihau	158.2	2.8	65.6	6.2	33.4	7.4	20.7	8.6
Kauai	227.5	4.0	45.6	4.3	58.6	13.0	21.0	8.7
Oahu	646.0	11.3	188.0	17.7	47.1	10.5	18.9	7.9
Maui Nui	2950.3	51.4	341.8	32.2	139.1	30.9	43.5	18.1
Hawaii	1640.7	28.6	369.7	34.9	139.4	31.0	120.9	50.4
Total km^2	**5736.8**		**1060.6**		**449.3**		**240.1**	
% of Total Modified EFH	**100.0**		**18.5**		**7.8**		**4.2**	

Table 1(a). Summary of modified EFH, hardbottom, and suitable habitat statistics under various management schemes.

Habitat Designation/Management Scheme	Total Area (km^2)	Percentage (%)
Modified EFH	5736.8	100 of total modified EFH
Hard bottom	1060.6	18.5 of total modified EFH
Greater than 20° slope habitat	449.3	7.8 of total modified EFH
Suitable habitat	240.1	4.2 of total modified EFH
Suitable habitat in existing state BRFAs	22.1	9.2 of total suitable habitat
Suitable habitat in proposed state BRFAs	26.9	11.2 of total suitable habitat
Suitable habitat in Proposed WPFMC BRFAs	20.6	8.6 of total suitable habitat
Suitable habitat in combined state and WPFMC BRFAs	42.4	17.7 of total suitable habitat

Table 2. Area (km^2) of modified EFH, hard substrate, 20° slope, and suitable habitat within and outside the State of Hawaii three-mile limit.

Island Area	Modified EFH		Hard Substrate		Slopes		Suitable Habitat	
	Within Three-mile Limit							
	km^2	% of total	km^2	% of total	km^2	% of total	km^2	% of total
Middle Bank	0	0	0	0	0	0	0	0
Kaula Rock	12.7	0.5	5.3	0.9	10.1	3.2	4.4	2.3
Niihau	116.2	4.3	39.9	7.3	30.4	9.6	16.5	8.8
Kauai	170.8	6.3	36.5	6.7	56.7	17.8	18.8	9.9
Oahu	284.9	10.5	76.6	13.9	40.4	12.7	16.5	8.8
Maui Nui	1158.5	42.8	99.9	18.2	61.3	19.3	14.9	7.9
Hawaii	964.4	35.6	290.2	52.9	118.9	37.4	116.9	62.2
Total km^2	**2707.5**		**548.4**		**317.8**		**187.9**	
% of Total Modified EFH and Respective Habitats		**47.2**		**51.7**		**70.7**		**78.3**

Island Area	Modified EFH		Hard Substrate		Slopes		Suitable Habitat	
	Outside Three-mile Limit							
	km^2	% of total	km^2	% of total	km^2	% of total	km^2	% of total
Middle Bank	85.1	2.8	39.1	7.6	12.1	9.2	7.5	14.4
Kaula Rock	16.2	0.5	5.4	1.1	9.5	7.2	3.2	6.1
Niihau	41.9	1.4	25.7	5.0	3.0	2.3	4.2	8.1
Kauai	56.8	1.9	9.1	1.8	1.9	1.5	2.2	4.3
Oahu	361.1	11.9	111.5	21.8	6.7	5.1	2.4	4.7
Maui Nui	1791.8	59.2	241.8	47.2	77.7	59.1	28.5	54.7
Hawaii	676.3	22.3	79.5	15.5	20.5	15.6	4.1	7.8
Total km^2	**3029.3**		**512.2**		**131.6**		**52.2**	
% of Total Modified EFH and Respective Habitats		**52.8**		**48.3**		**29.3**		**21.7**

Table 3. Area (km^2) of modified EFH, hard substrate, 20° slope, suitable habitat, and existing State of Hawaii RFAs, by island area.

Island Area	RFA		Modified EFH		Hard Substrate		Slopes > 20 Degrees		Suitable Habitat	
	km^2	% of total	km^2	% of total	km^2	% of total	km^2	% of total	km^2	% of total
Middle Bank	0		0		0		0		0	
Kaula Rock	0		0		0		0		0	
Niihau	50.2	6.0	25.4	6.1	11.9	14.6	2.7	6.7	2.0	9.1
Kauai	45.9	5.5	21.6	5.2	5.2	6.4	6.7	16.5	2.1	9.3
Oahu	58.7	7.0	31.4	7.5	8.9	11.0	4.8	11.8	2.4	10.7
Maui Nui	380.7	45.4	235.1	56.2	20.9	25.6	9.8	24.1	3.8	17.2
Hawaii	302.5	36.1	105.0	25.1	34.8	42.5	16.8	41.0	11.9	53.7
Total Area and % of RFA	**838.0 km^2**	**100%**	**418.6 km^2**	**49.9%**	**81.9 km^2**	**9.8%**	**40.9 km^2**	**4.9%**	**22.1 km^2**	**2.6%**
% of Total Modified EFH and Respective Habitats			**7.3**		**7.7**		**9.1**		**9.2**	

Table 4. Area (km^2) of modified EFH, hard substrate, 20° slope, suitable habitat, and proposed State of Hawaii RFAs, by island area.

Island Area	RFA		Modified EFH		Hard Substrate		Slopes > 20 Degrees		Suitable Habitat	
	km^2	% of total	km^2	% of total	km^2	% of total	km^2	% of total	km^2	% of total
Middle Bank	0	0	0	0	0	0	0	0	0	0
Kaula Rock	85.9	4.1	12.9	1.8	3.9	1.6	7.7	11.2	2.6	8.9
Niihau	40.8	2.0	26.4	3.7	11.7	4.8	3.6	5.2	2.3	8.4
Kauai	50.8	2.5	14.3	2.0	7.9	3.2	7.9	11.6	5.3	19.7
Oahu	274.1	13.2	97.8	13.8	49.5	20.2	3.9	5.7	1.1	4.2
Maui Nui	541.3	26.1	185.2	26.1	48.2	19.7	29.6	43.3	6.7	25.0
Hawaii	1079.0	52.1	373.7	52.6	123.3	50.4	15.7	22.9	9.1	33.7
Total Area and % of RFA	**2071.9 km^2**	**100%**	**710.4 km^2**	**34.3%**	**244.6 km^2**	**11.8%**	**68.4 km^2**	**3.3%**	**26.9 km^2**	**1.3%**
% of Total Modified EFH and Respective Habitats			**12.4**		**23.1**		**15.2**		**11.2**	

Table 5. Area (km^2) of modified EFH, hard substrate, 20° slope, suitable habitat, and proposed WPFMC RFAs, by island area.

Island Area	RFA		Modified EFH		Hard Substrate		Slopes > 20 Degrees		Suitable Habitat	
	km^2	% of total	km^2	% of total	km^2	% of total	km^2	% of total	Km^2	% of total
Middle Bank	799.9	35.8	85.1	25.8	39.1	58.7	10.4	19.8	7.5	36.5
Kaula Rock	0	0	0	0	0	0	0	0	0	0
Niihau	0	0	0	0	0	0	0	0	0	0
Kauai	0	0	0	0	0	0	0	0	0	0
Oahu	0	0	0	0	0	0	0	0	0	0
Maui Nui	1436.7	64.2	244.9	74.2	27.4	41.3	41.9	80.2	13.1	63.5
Hawaii	0	0	0	0	0	0	0	0	0	0
Total Area and % of RFA	**2236.6 km^2**	**100%**	**330.0 km^2**	**14.8%**	**66.5 km^2**	**3.0%**	**52.3 km^2**	**2.3%**	**20.6 km^2**	**0.9%**
% of Total Modified EFH and Respective Habitats				**5.8**		**6.3**		**11.6**		**8.6**

Table 6. Area (km^2) of modified EFH, hard substrate, 20° slope, suitable habitat, and combined proposed RFAs of State of Hawaii and WPFMC, by island area.

Island Area	RFA		Modified EFH		Hard Substrate		RFA Slopes		Suitable Habitat	
	km^2	% of total	km^2	% of total	km^2	% of total	km^2	% of total	km^2	% of total
Middle Bank	79.9	19.8	85.1	8.9	39.1	13.1	10.4	10.1	7.5	17.7
Kaula Rock	85.9	2.1	12.9	1.4	3.9	1.3	7.7	7.5	2.4	5.7
Niihau	40.8	1.0	26.4	2.8	11.7	3.9	3.6	3.5	2.3	5.4
Kauai	50.8	1.3	14.3	1.5	8.3	2.8	7.9	7.8	5.4	12.7
Oahu	274.1	6.8	96.6	10.1	48.7	16.3	6.1	5.9	1.1	2.7
Maui Nui	1714.6	42.4	348.9	36.4	63.8	21.4	50.9	49.8	14.7	34.5
Hawaii	1079.0	26.7	373.7	39.0	123.3	41.3	15.7	15.3	9.1	21.4
Total Area and % of RFA	**4045.1 km^2**		**958.0 km^2**	**23.7%**	**298.8 km^2**	**7.4%**	**102.2 km^2**	**2.5%**	**42.4 km^2**	**1.0%**
% of Total Modified EFH and Respective Habitats				**16.7**		**28.2**		**22.8**		**17.7**

Table 7. Area (km^2) of modified EFH, hard substrate, 20° slope, suitable habitat, and proposed State of Hawaii RFAs, by island area inside and outside the State of Hawaii three-mile limit.

Island Area	Proposed RFA		Modified EFH		Hard Substrate		Slopes		Suitable Habitat	
	Within Three-mile Limit									
	km^2	% of total	Km^2	% of total	km^2	% of total	km^2	% of total	km^2	% of total
Middle Bank	0	0	0	0	0	0	0	0	0	0
Kaula Rock	15.3	0.7	2.0	0.29	0.6	0.24	1.6	2.36	0.5	1.91
Niihau	9.9	0.5	7.4	1.04	8.3	3.41	0.9	1.36	0.4	1.31
Kauai	50.7	2.4	14.3	2.01	7.9	3.23	7.9	11.62	5.3	19.64
Oahu	66.9	3.2	24.9	3.51	1.3	0.52	2.5	3.59	0.3	1.03
Maui Nui	158.9	7.	71.4	10.05	12.2	5.00	13.2	19.23	1.4	5.34
Hawaii	388.3	18.7	255.8	36.01	69.4	28.36	8.1	11.89	8.1	30.17
Total Area and % of RFA	**690.3 km^2**	**33.3%**	**375.9 km^2**	**52.9%**	**99.7 km^2**	**40.8%**	**34.2 km^2**	**50.1%**	**16.0 km^2**	**59.4%**
% of Total Modified EFH and Respective Habitats				**6.6**		**9.4**		**7.6**		**6.7**

Island Area	Proposed RFA		Modified EFH		Hard Substrate		Slopes		Suitable Habitat	
	Outside Three-mile Limit									
	km^2	% of total	km^2	% of total	km^2	% of total	km^2	% of total	km^2	% of total
Middle Bank	0	0	0	0	0	0	0	0	0	0
Kaula Rock	70.6	3.4	10.9	1.54	33.6	1.37	6.1	8.88	1.9	7.02
Niihau	30.8	1.	19.0	2.68	33.6	1.37	2.6	3.86	1.9	7.12
Kauai	0.1	0	0	0	0	0	0	0	0	0
Oahu	207.1	10.0	72.8	10.25	48.2	19.71	1.4	2.11	0.9	3.19
Maui Nui	382.4	18.5	113.8	16.02	35.9	14.71	16.4	24.04	5.3	19.69
Hawaii	690.7	33.3	117.9	16.60	53.9	22.06	7.6	11.05	0.9	3.56
Total Area and % of RFA	**1381.7 km^2**	**66.7%**	**334.5 km^2**	**47.1%**	**144.9 km^2**	**59.2%**	**34.2 km^2**	**49.9%**	**10.9 km^2**	**40.6%**
% of Total Modified EFH and Respective Habitats				**5.8**		**13.7**		**7.6**		**4.6**

Table 8. Catch of onaga (pounds) in 2005 within each RFA under various management schemes.

RFAs by Location	Onaga Catch within SOH RFA Allocated by % Suitable Habitat within RFA (lbs)	Onaga Catch within Reporting Zones Coincident to SOH RFAs Irrespective of Habitat (lbs)	Onaga Catch within Reporting Zones Surrounding Islands or Banks Irrespective of Habitat (lbs)
Middle Bank	0	0	confidential
Kaula (A)	34	327	327
Niihau (B)	111	209	3598
Kauai (C)	1321	2282	5642
W. Oahu (D)	97	1408	
E. Oahu (E)	1687	2461	10,790[1]
Penguin Bank[2] (F)	5614	13,713	18,745[2]
Molokai (G)	337	740	2066[3]
W. Maui (H)	65	1485	
N.E. Maui (J)	791	1163	21,243[4]
N. Hawaii (K)	971	1949	
E. Hawaii (L)	3494	8209	21176
S. Hawaii (M)	488	3772	
Totals	**17,545**	**37,718**	**83,587[5]**

	Onaga Catch within WPFMC RFA allocated by % suitable habitat within RFA (lbs)	Onaga Catch within Reporting Zones Coincident to WPFMC RFAs irrespective of habitat (lbs)	Onaga Catch within Reporting Zones Surrounding Islands or Banks irrespective of habitat (lbs)
Middle Bank	confidential	confidential	confidential
Penguin Bank[2]	14,091	18,745	18,745[2]
Totals[6]	**14,091**	**18,745**	**18,745**

[1] Reporting areas 420 and 429 not included in Oahu total, but in Penguin Bank total.
[2] Penguin Bank total catch numbers for the "Catch within Reporting Zones Surrounding Islands or Banks" are identical because totals include the entire Penguin Bank reported catch and the total reported catch from all of the reporting grids surrounding Penguin Bank. Penguin Bank totals include reporting zones 328, 331, 332, 351, 420, 429, 452.
[3] Molokai total catch from reporting areas 310, 311, 312, 313, 314, 332, 333.
[4] Maui total catch includes reporting areas 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 320, 321, 322, 323, 324, 325, 326, 327.
[5] Actual total is less than summative total to compensate for reporting area 332 being counted twice. Total reported 2005 Onaga catch for main Hawaiian Islands was 83950 pounds. Table 4 totals do not include catch reported outside of analysis zones.
[6] Does not include Middle Bank due to confidentiality of data.

Table 9. Catch of opakapaka (pounds) in 2005 within each RFA under various management schemes.

RFAs by Location	Opakapaka Catch within SOH RFA Allocated by % Suitable Habitat within RFA (lbs)	Opakapaka Catch within Reporting Zones Coincident to SOH RFAs Irrespective of Habitat (lbs)	Opakapaka Catch within Reporting Zones Surrounding Islands or Banks Irrespective of Habitat (lbs)
Middle Bank	0	0	confidential
Kaula (A)	326	1121	1121
Niihau (B)	118	222	4555
Kauai (C)	783	1187	5354
W. Oahu (D)	56	1754	
E. Oahu (E)	869	938	10,636[1]
Penguin Bank[2] (F)	4695	8340	12,473[2]
Molokai (G)	290	771	2479[3]
W. Maui (H)	159	3622	
N.E. Maui (J)	5074	7270	24,341[4]
N. Hawaii (K)	1786	2579	
E. Hawaii (L)	2140	6820	19,265
S. Hawaii (M)	232	4552	
Totals	**16,528**	**39,176**	**80,224[5]**

	Opakapaka Catch within WPFMC RFA Allocated by % Suitable Habitat within RFA (lbs)	Opakapaka Catch within Reporting Zones Coincident to WPFMC RFAs Irrespective of Habitat (lbs)	Opakapaka Catch within Reporting Zones Surrounding Islands or Banks Irrespective of Habitat (lbs)
Middle Bank	Confidential	confidential	confidential
Penguin Bank[2]	8638	12,473	12,473[2]
Totals[6]	**8638**	**12,473**	**12,473**

[1] Reporting areas 420 and 429 not included in Oahu total, but in Penguin Bank total.
[2] Penguin Bank total catch numbers for the "Catch within Reporting Zones Surrounding Islands or Banks" are identical because totals include the entire Penguin Bank reported catch and the total reported catch from all of the reporting grids surrounding Penguin Bank. Penguin Bank totals include reporting zones 328, 331, 332, 351, 420, 429, 452.
[3] Molokai total catch from reporting areas 310, 311, 312, 313, 314, 332, 333.
[4] Maui total catch includes reporting areas 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 320, 321, 322, 323, 324, 325, 326, 327.
[5] Actual total is less than summative total to compensate for reporting area 332 being counted twice and confidentiality of Middle Bank data. Total reported 2005 Paka catch for main Hawaiian Islands was 80997 pounds. Table 4 totals do not include catch reported outside of analysis zones.
[6] Does not include Middle Bank due to confidentiality of data.

Table 10. Catch of ehu (pounds) in 2005 within each RFA under various management schemes.

RFAs by Location	Ehu Catch within SOH RFA Allocated by % Suitable Habitat within RFA (lbs)	Ehu Catch within Reporting Zones Coincident to SOH RFAs Irrespective of Habitat (lbs)	Ehu Catch within Reporting Zones Surrounding Islands or Banks Irrespective of Habitat (lbs)
Middle Bank	0	0	confidential
Kaula (A)	52	299	299
Niihau (B)	9	16	767
Kauai (C)	184	333	1799
W. Oahu (D)	35	840	
E. Oahu (E)	228	485	4290[1]
Penguin Bank[2] (F)	1069	2601	3634[2]
Molokai (G)	31	69	404[3]
W. Maui (H)	33	756	
N.E. Maui (J)	56	85	5217[4]
N. Hawaii (K)	223	555	
E. Hawaii (L)	607	3894	7914
S. Hawaii (M)	58	460	
Totals	**2585**	**10393**	**24324[5]**

	Ehu Catch within WPFMC RFA Allocated by % Suitable Habitat within RFA (lbs)	Ehu Catch within Reporting Zones Coincident to WPFMC RFAs Irrespective of Habitat (lbs)	Ehu Catch within Reporting Zones Surrounding Islands or Banks Irrespective of Habitat (lbs)
Middle Bank	confidential	confidential	confidential
Penguin Bank[2]	2808	3634	3634[2]
Totals[6]	2865	3750	3750

[1] Reporting areas 420 and 429 not included in Oahu total, but in Penguin Bank total.

[2] Penguin Bank total catch numbers for the "Catch within Reporting Zones Surrounding Islands or Banks" are identical because totals include the entire Penguin Bank reported catch and the total reported catch from all of the reporting grids surrounding Penguin Bank. Penguin Bank totals include reporting zones 328, 331, 332, 351, 420, 429, 452.

[3] Molokai total catch from reporting areas 310, 311, 312, 313, 314, 332, 333.

[4] Maui total catch includes reporting areas 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 320, 321, 322, 323, 324, 325, 326, 327.

[5] Actual total is less than summative total to compensate for reporting area 332 being counted twice and confidentiality of Middle Bank catch data. Total reported 2005 Ehu catch for main Hawaiian Islands was 24594 pounds. Table 4 totals do not include catch reported outside of analysis zones.

[6] Does not include Middle Bank due to confidentiality of data.

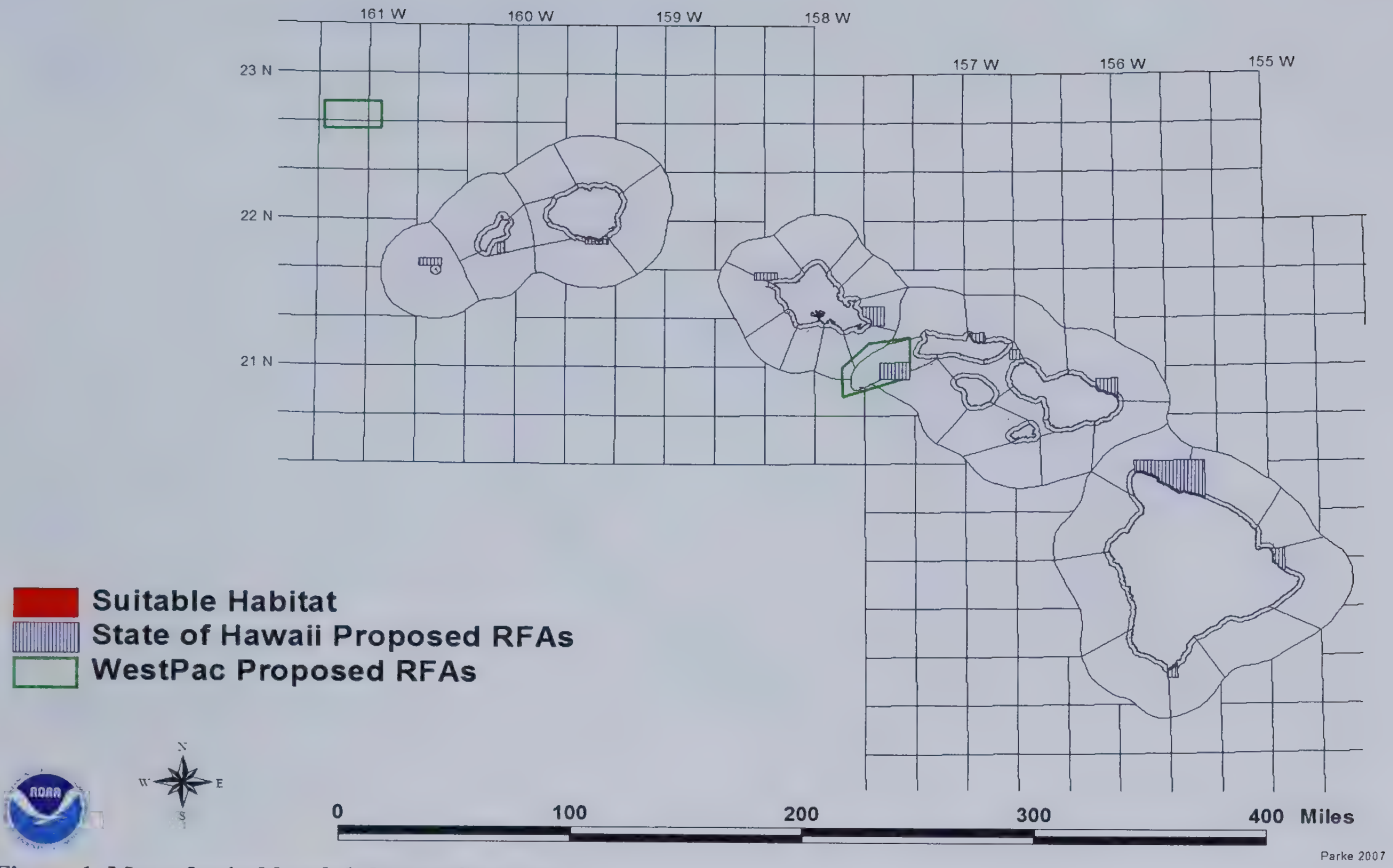

Figure 1. Map of suitable adult bottomfish habitat.

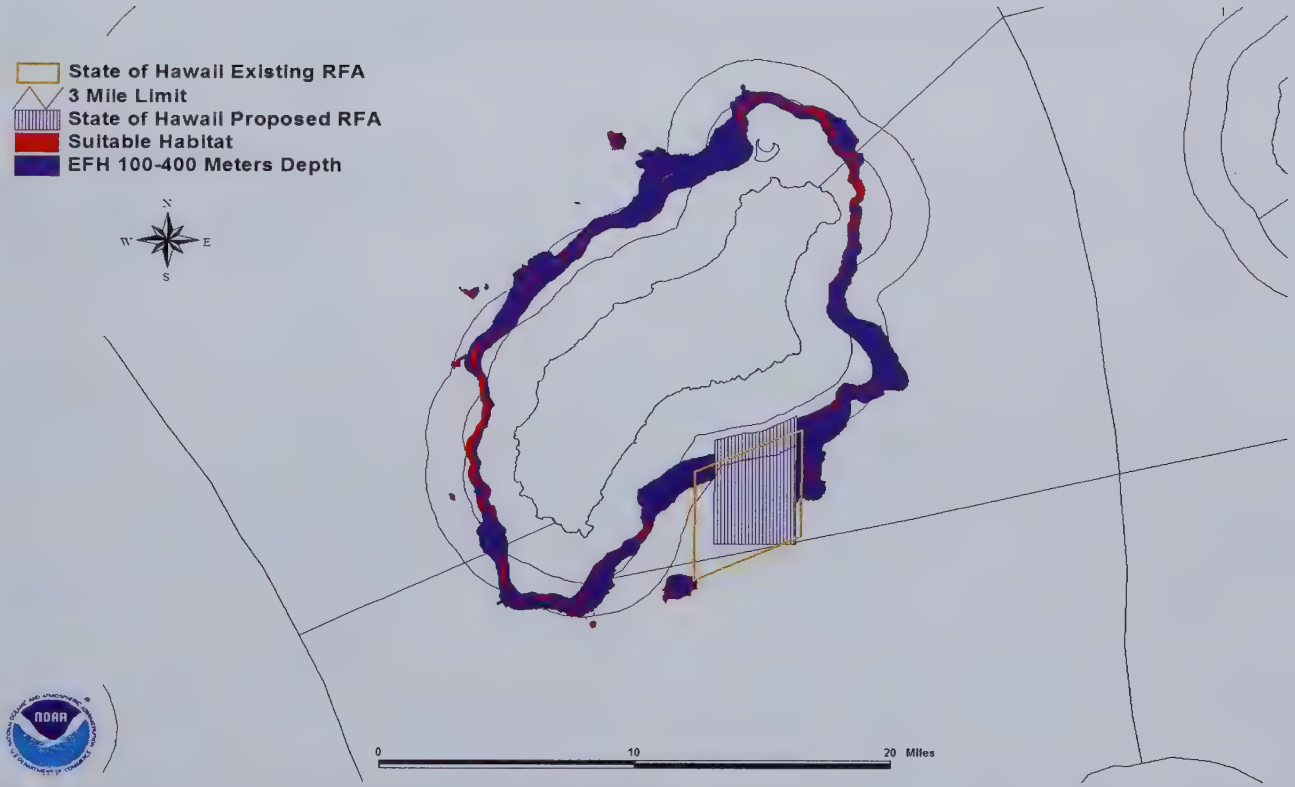

Figure 1a. Map of suitable adult bottomfish habitat – Niihau.

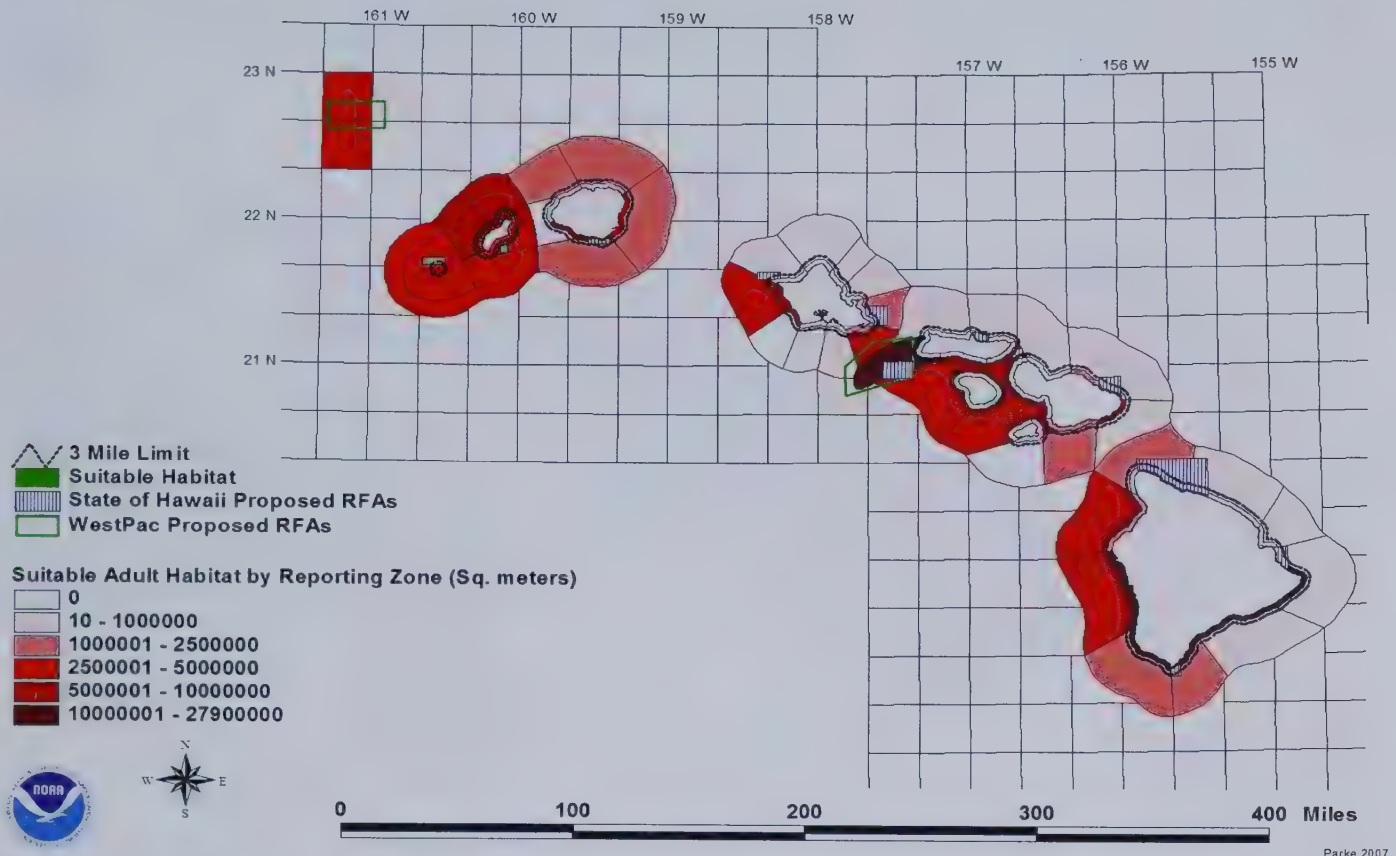

Figure 2. Map of State of Hawaii bottomfish habitat area (m^2) by state reporting zone.

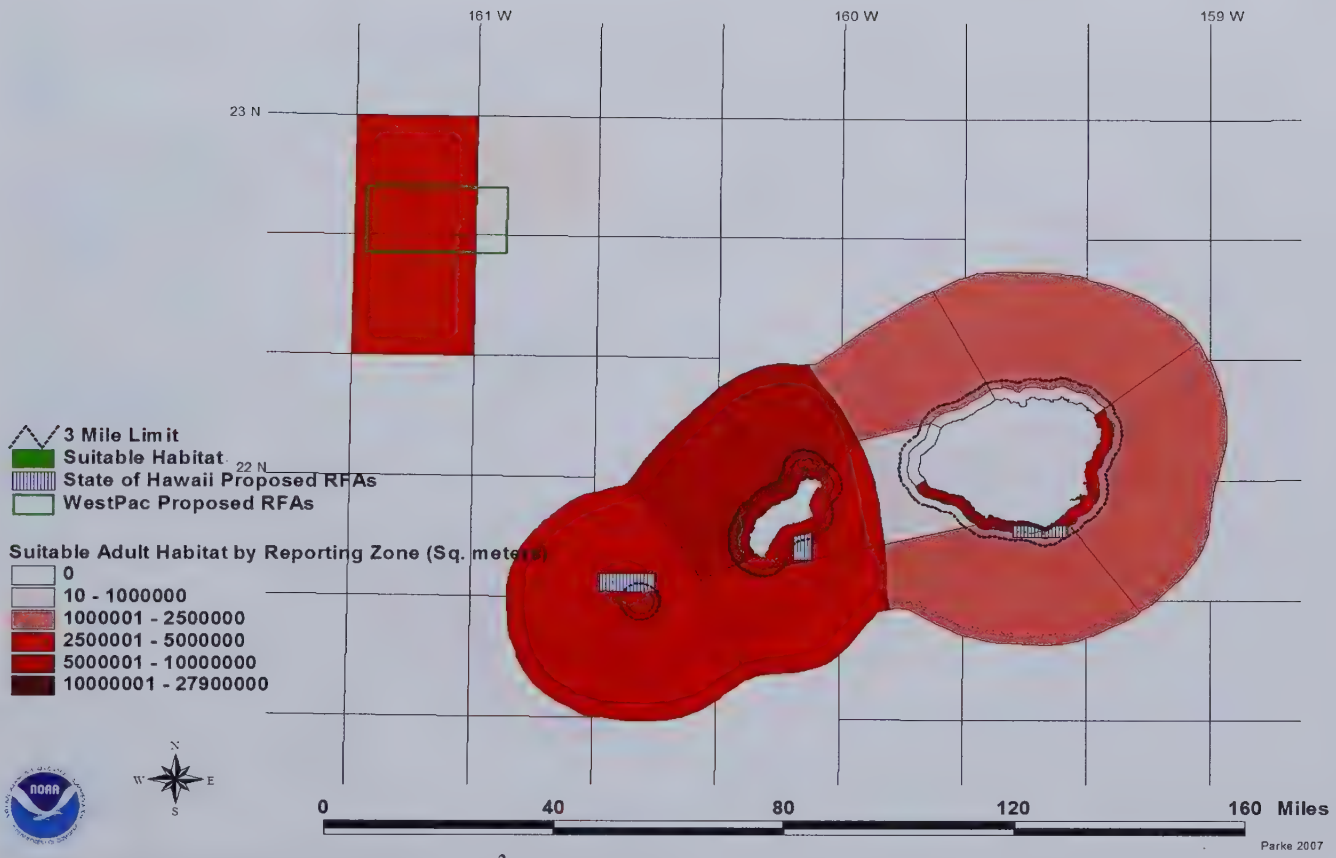

Figure 3. Map of bottomfish habitat area (m^2) in Kauai, Niihau, Kaula, and Middle Bank by state reporting zone.

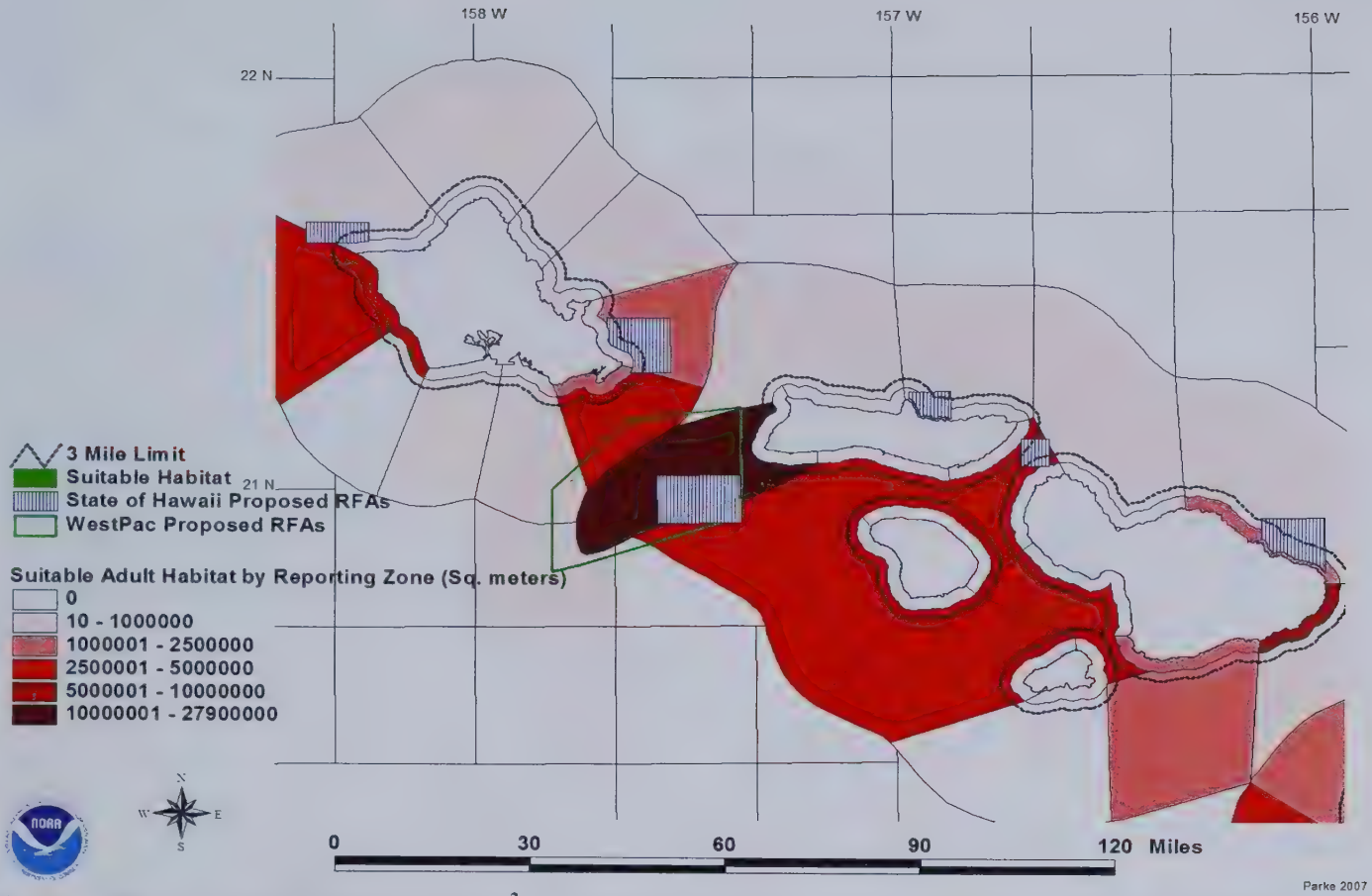

Figure 4. Map of bottomfish habitat area (m^2) in Honolulu County and Maui County (including Penguin Bank) by state reporting zone.

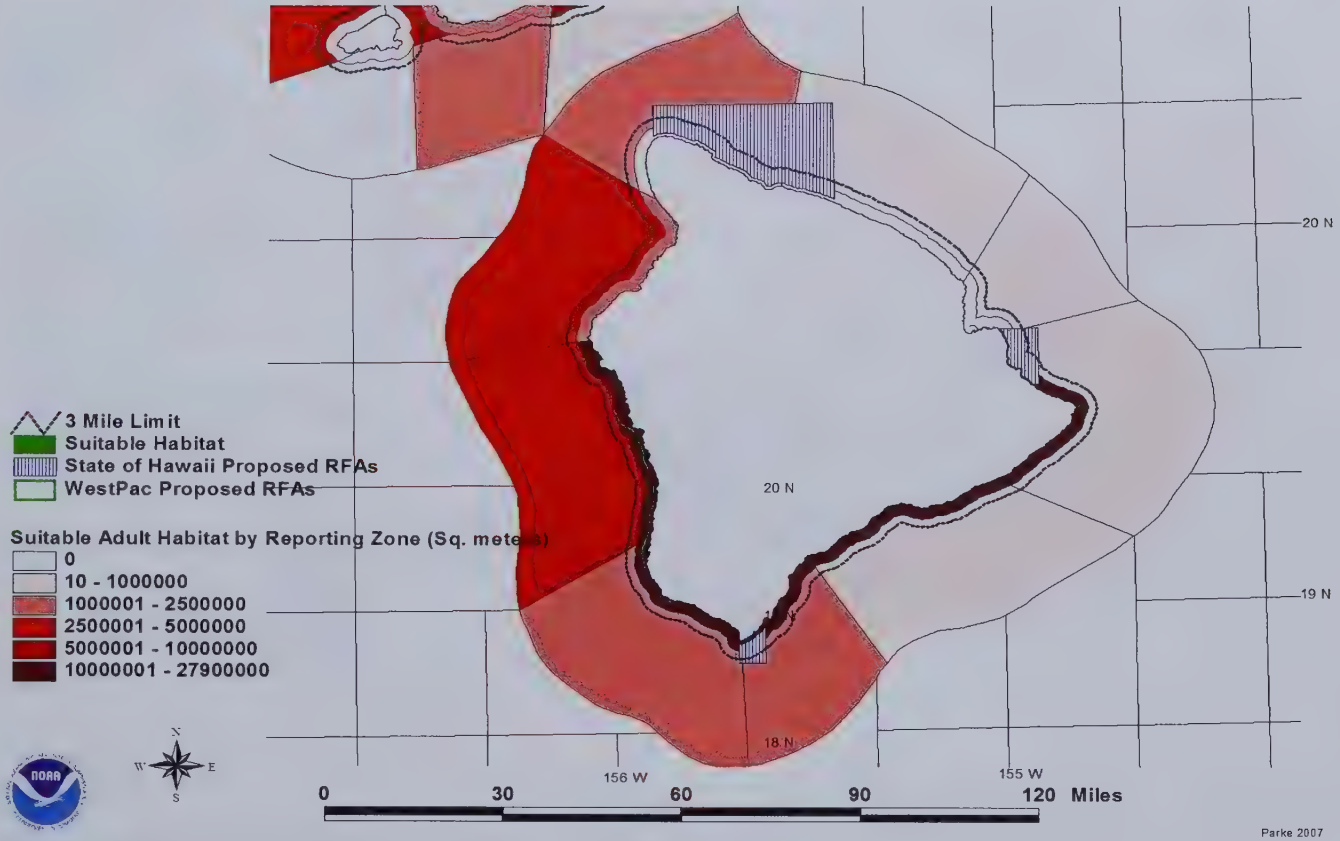

Figure 5. Map of Big Island bottomfish habitat area (m^2) by state reporting zone.

Figure 6. Map of percent suitable habitat by state reporting zone.

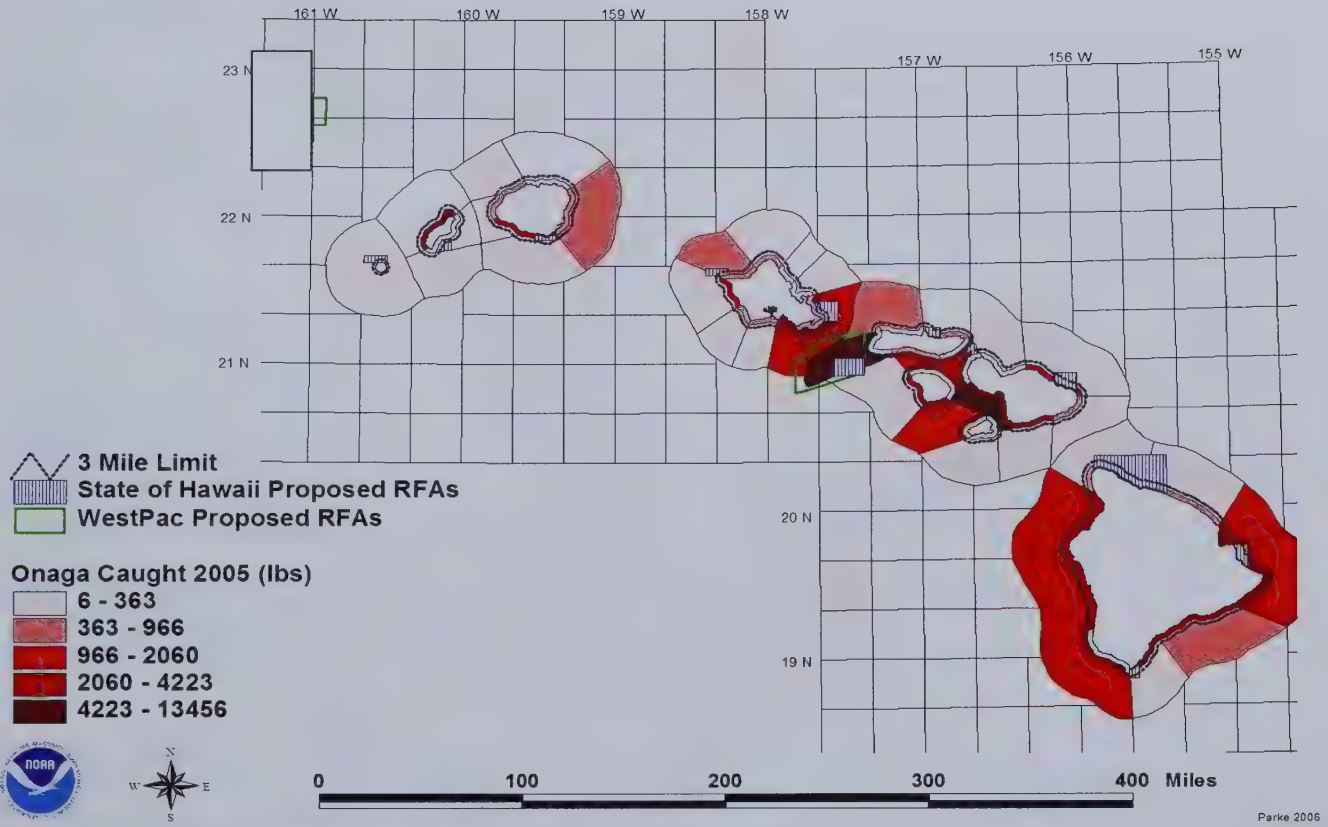

Figure 7. Map of 2005 onaga catch by reporting zone.

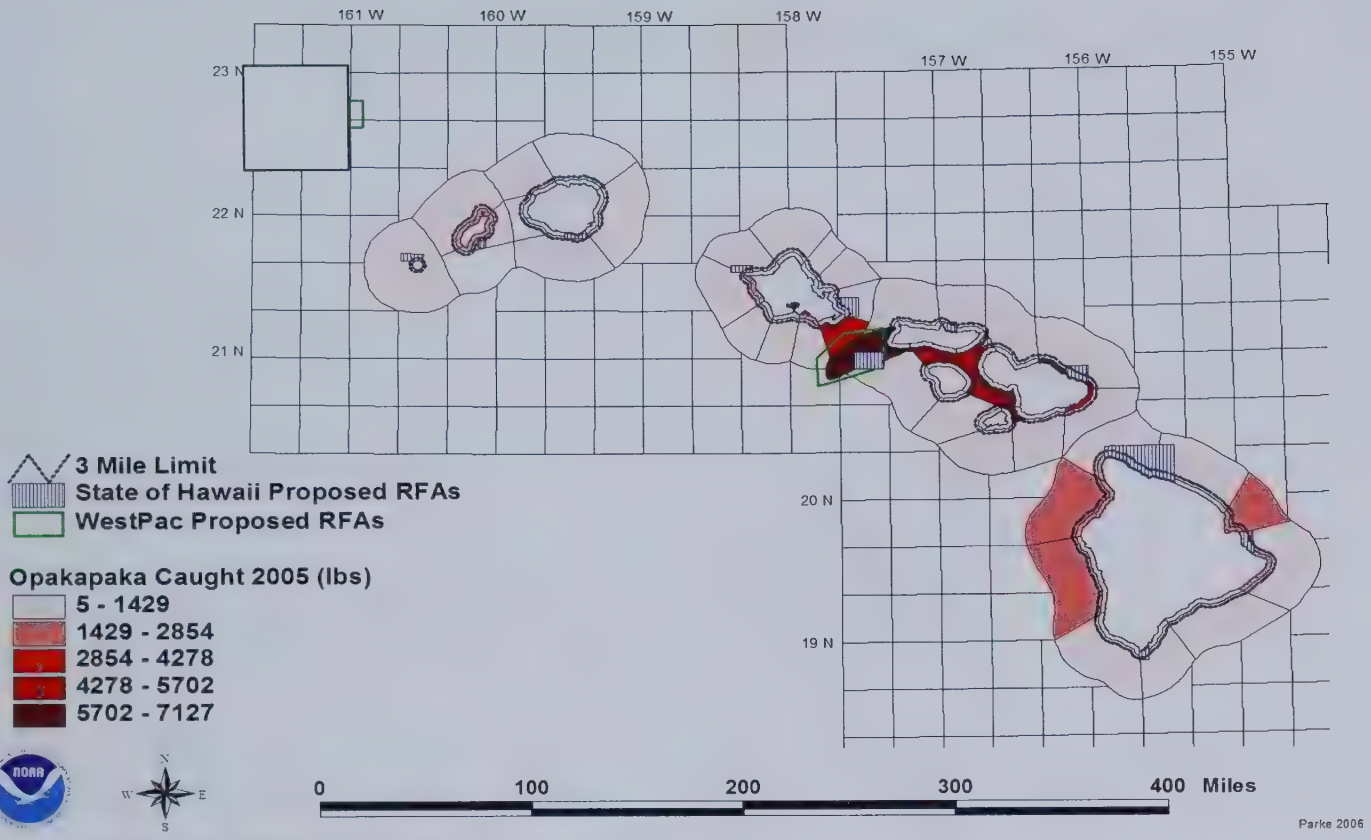

Figure 8. Map of 2005 opakapaka catch by reporting zone.

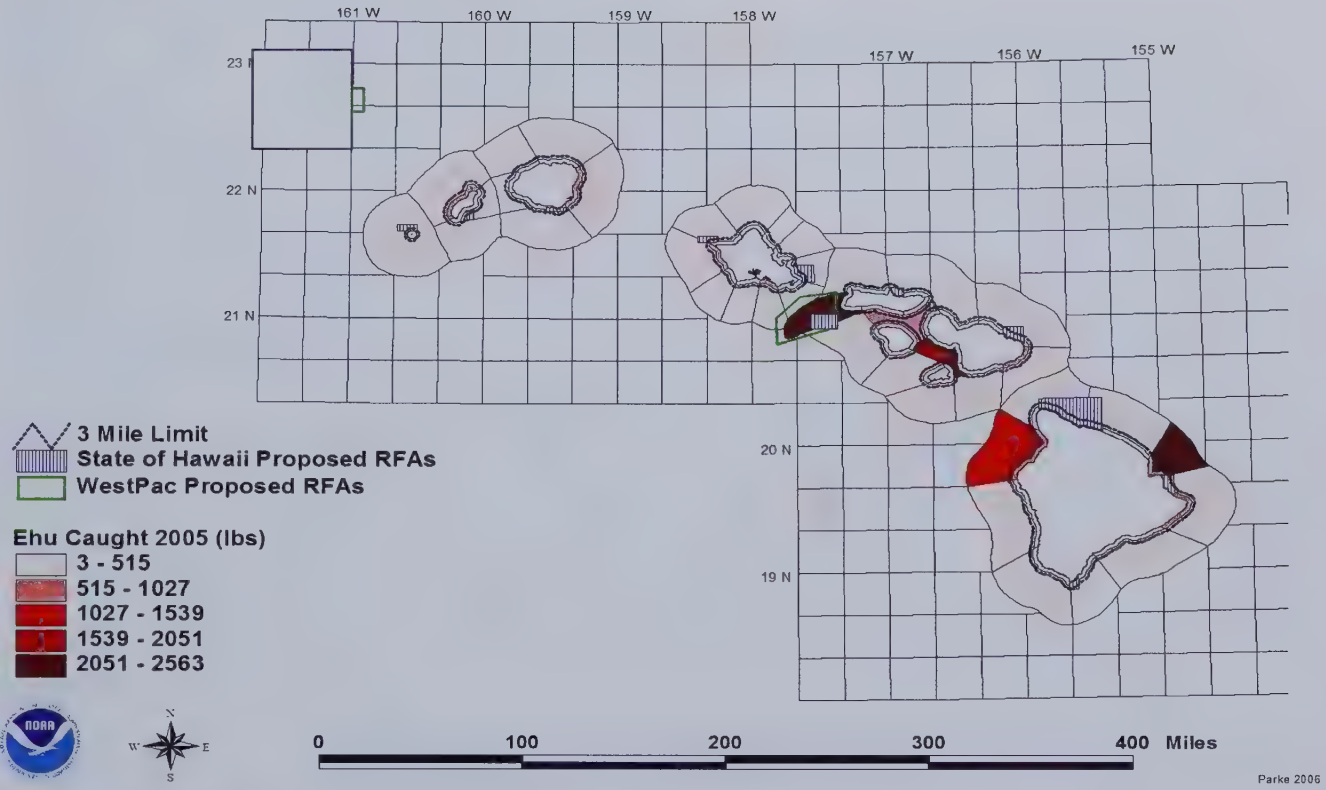

Figure 9. Map of 2005 ehu catch by reporting zone.

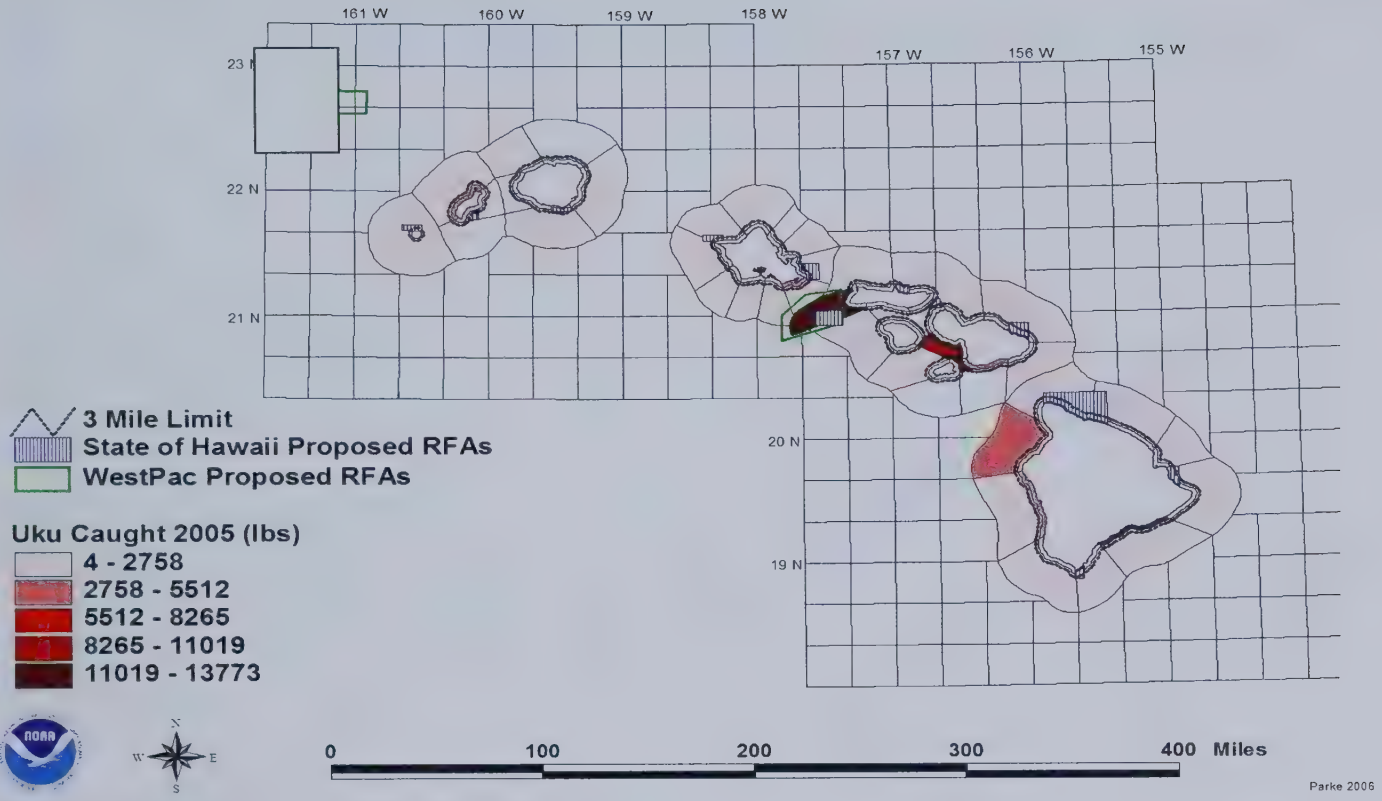

Figure 10. Map of 2005 uku catch by reporting zone.

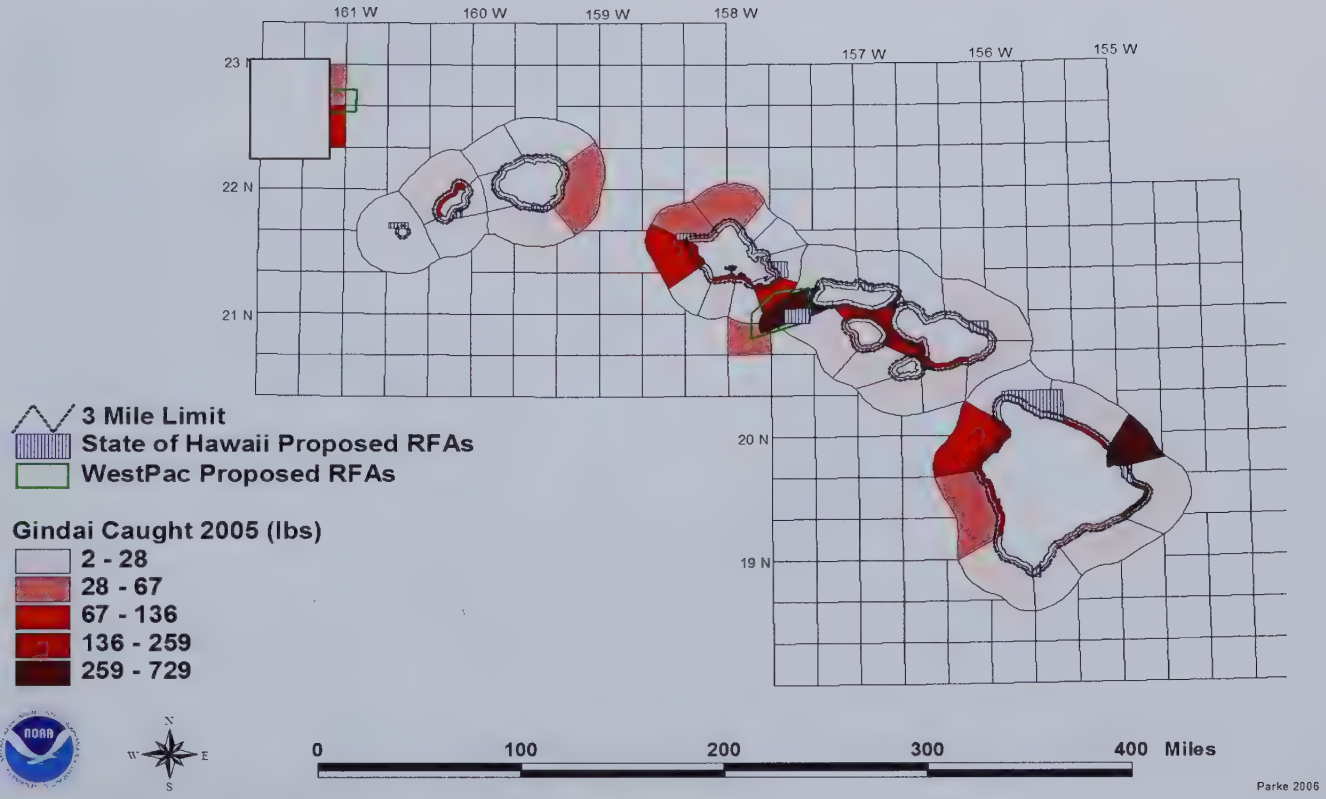

Figure 11. Map of 2005 gindai catch by reporting zone.

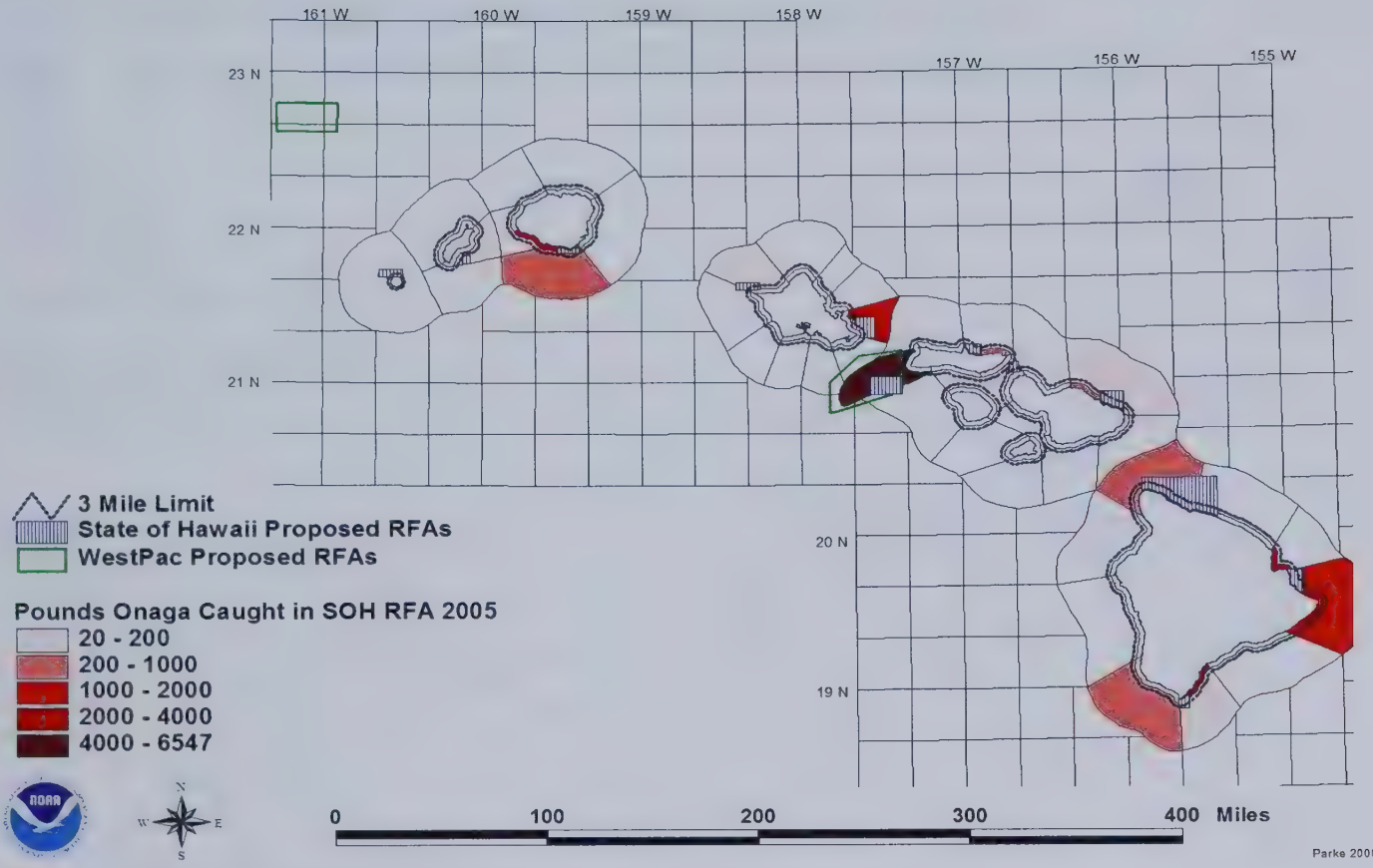

Figure 12. Map of 2005 onaga catch in State of Hawaii RFAs, by reporting zone.

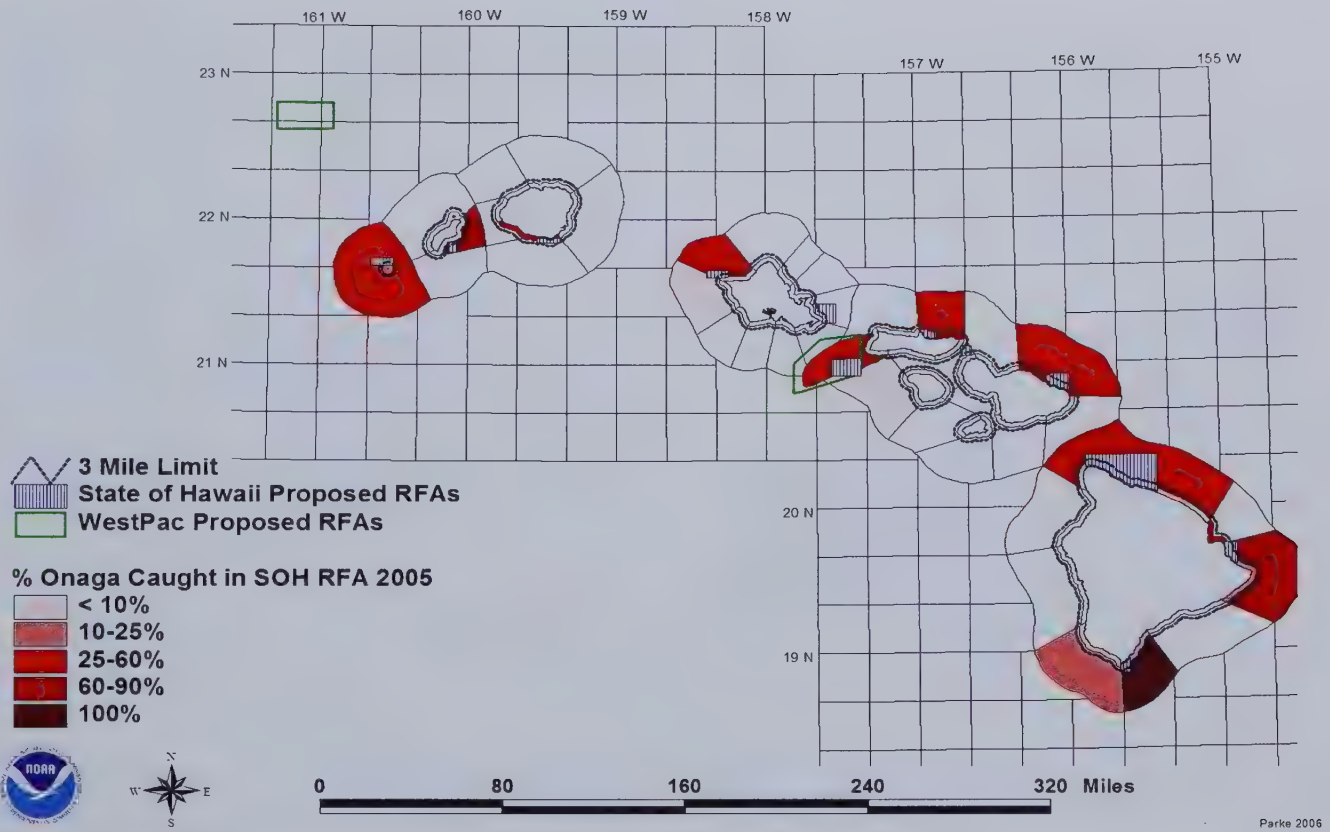

Figure 13. Map of percent 2005 onaga catch in State of Hawaii RFAs, by reporting zone.

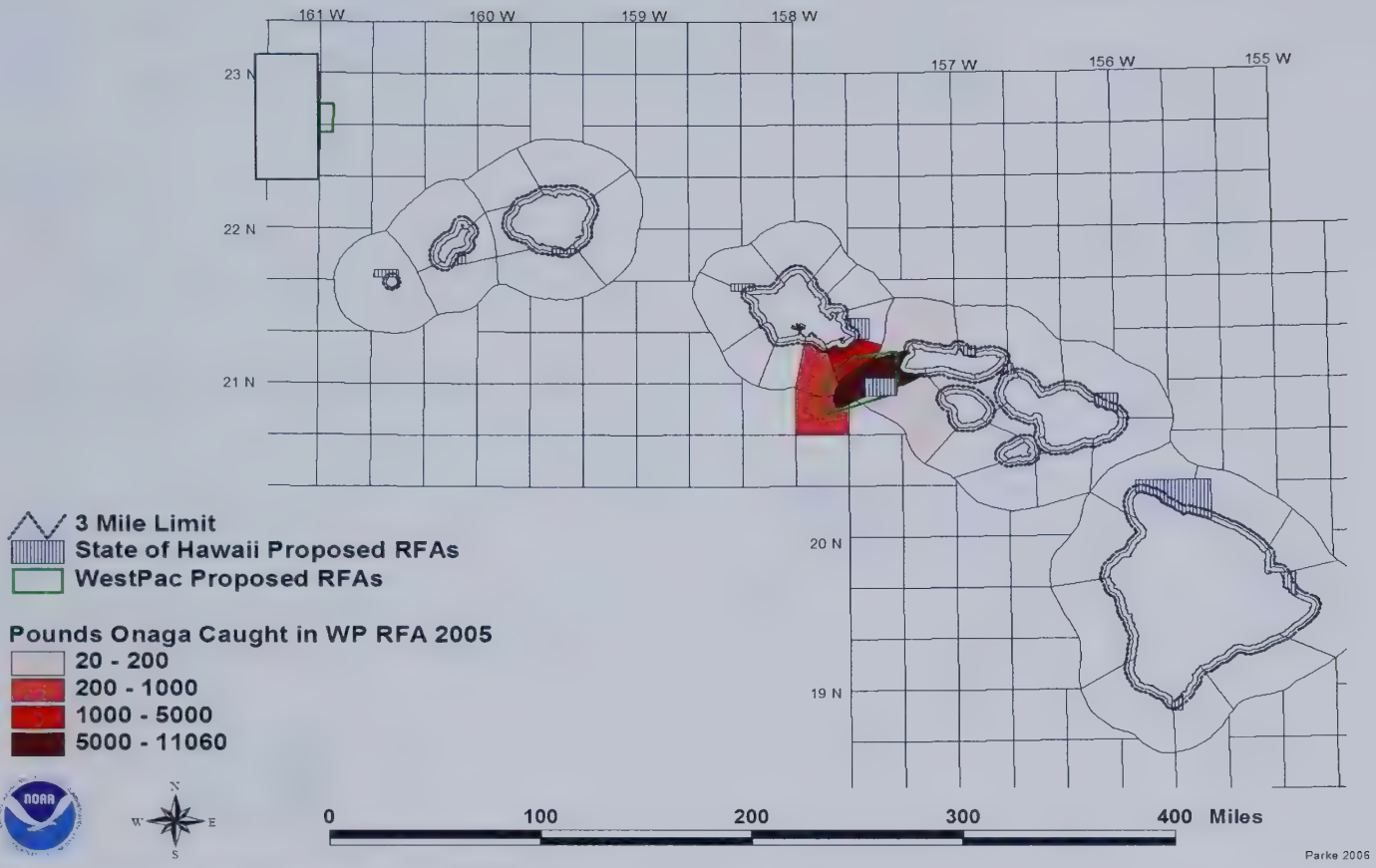

Figure 14. Map of 2005 onaga catch in WPFMC RFAs, by reporting zone.

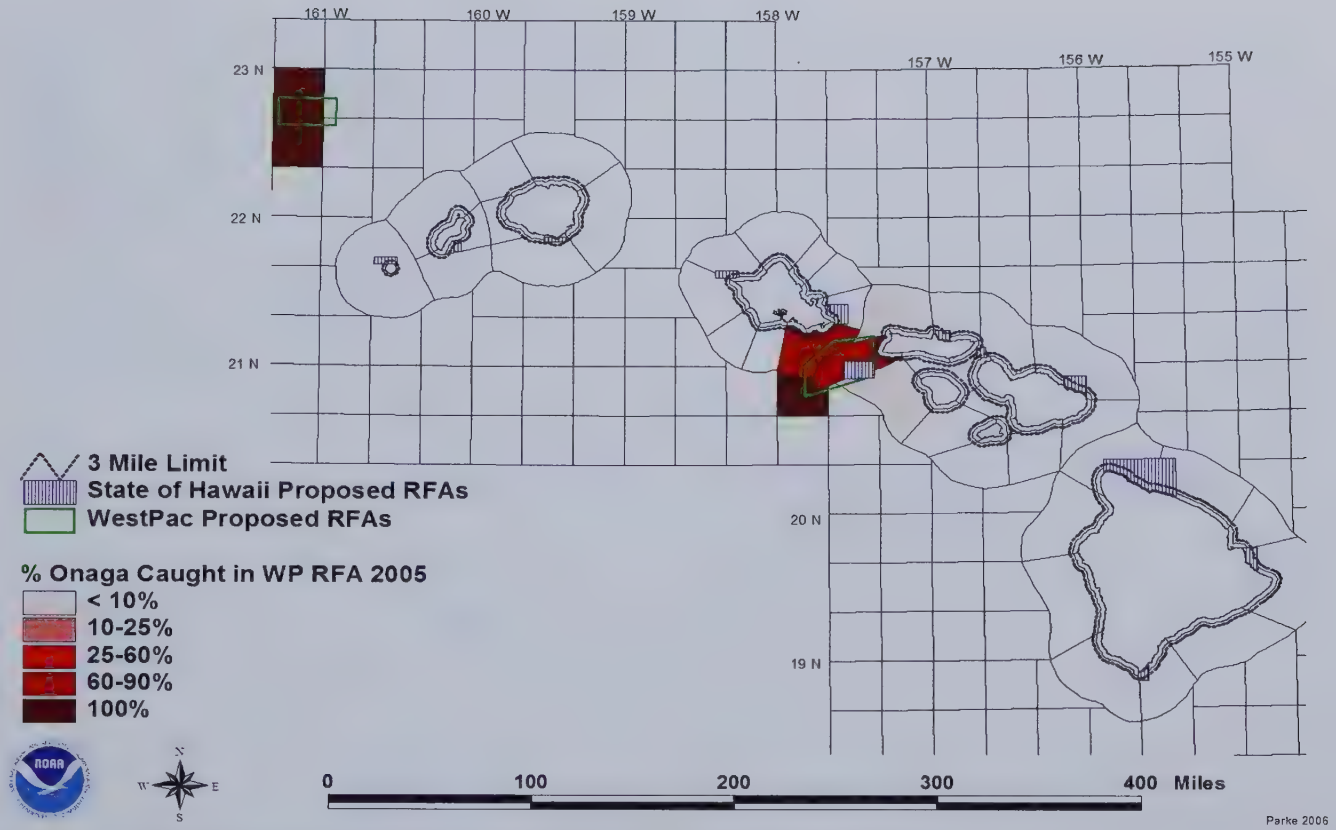

Figure 15. Map of percent 2005 onaga catch in WPFMC RFAs, by reporting zone.

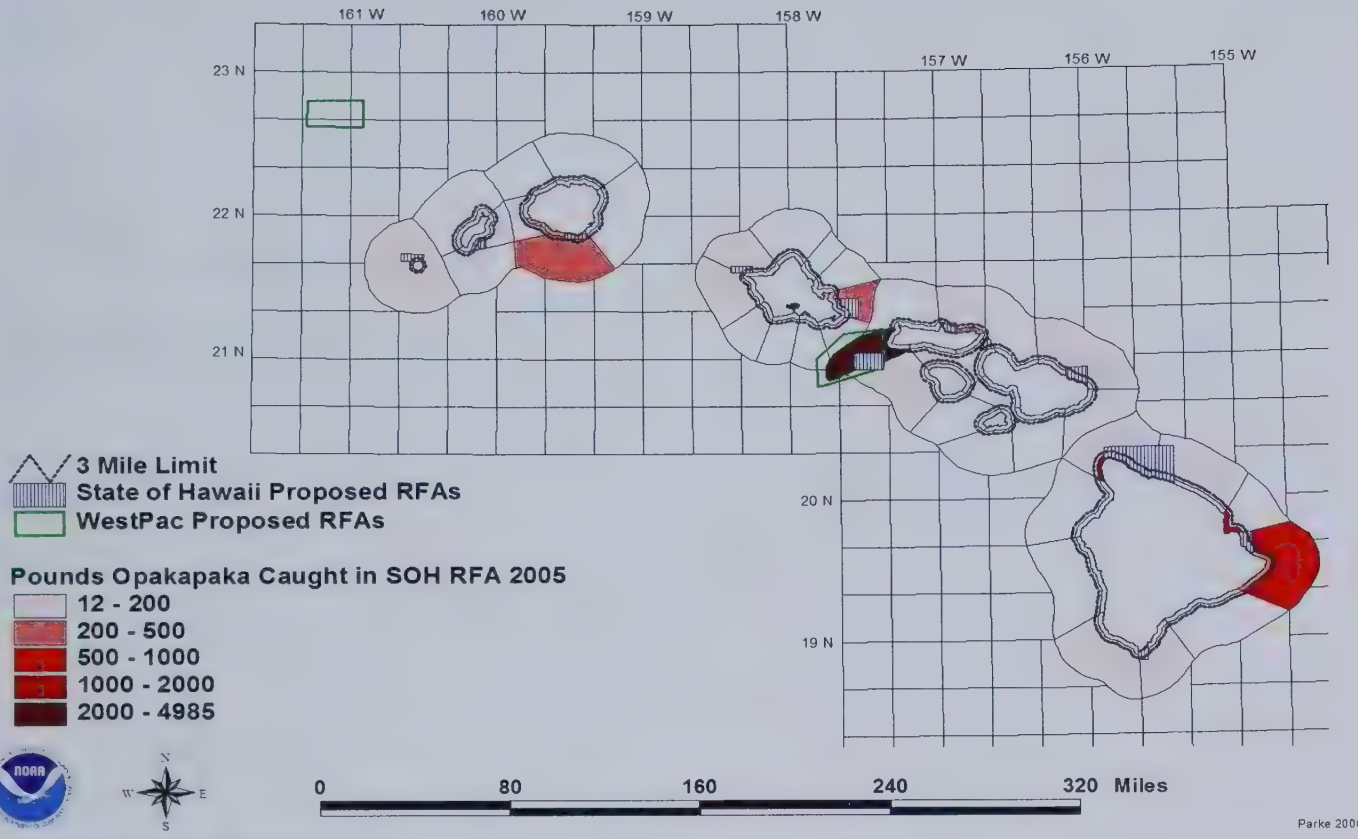

Figure 16. Map of 2005 opakapaka catch in State of Hawaii RFAs, by reporting zone.

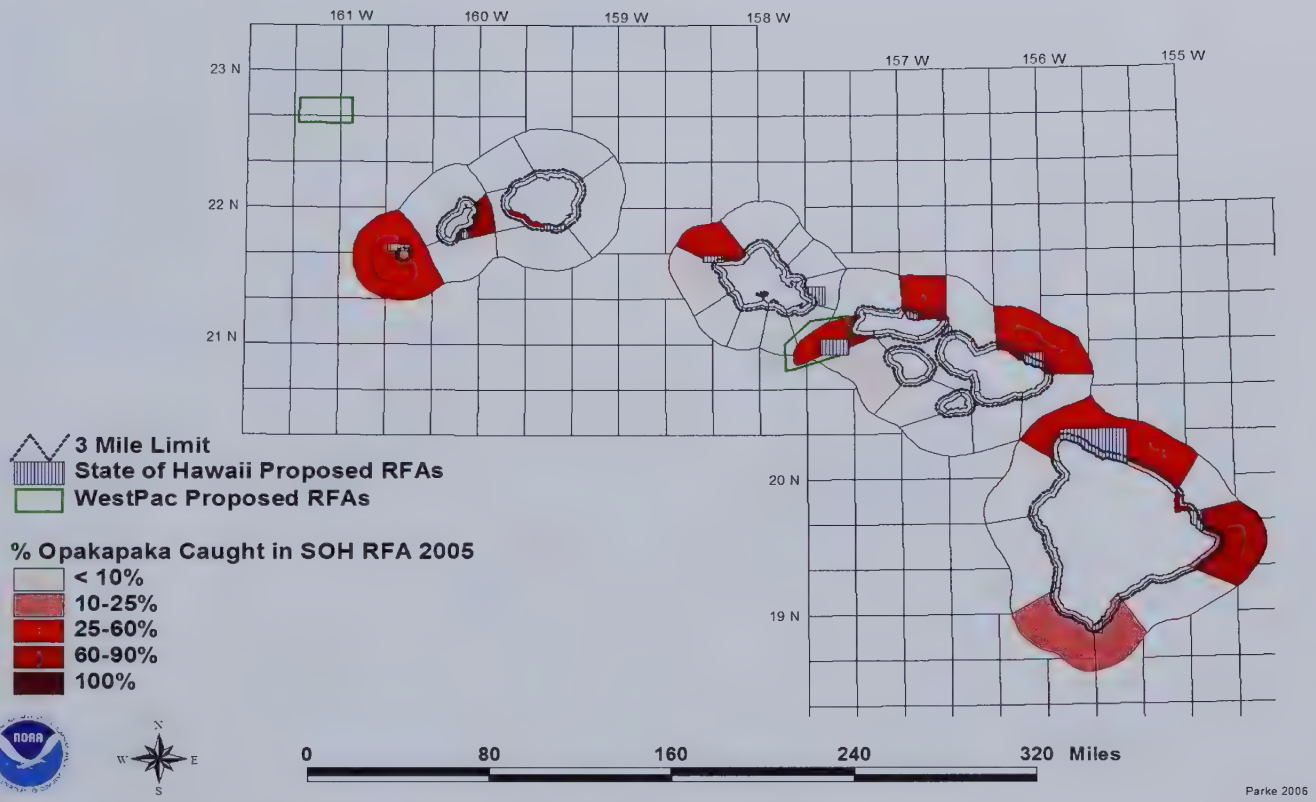

Figure 17. Map of percent 2005 opakapaka catch in State of Hawaii RFAs, by reporting zone.

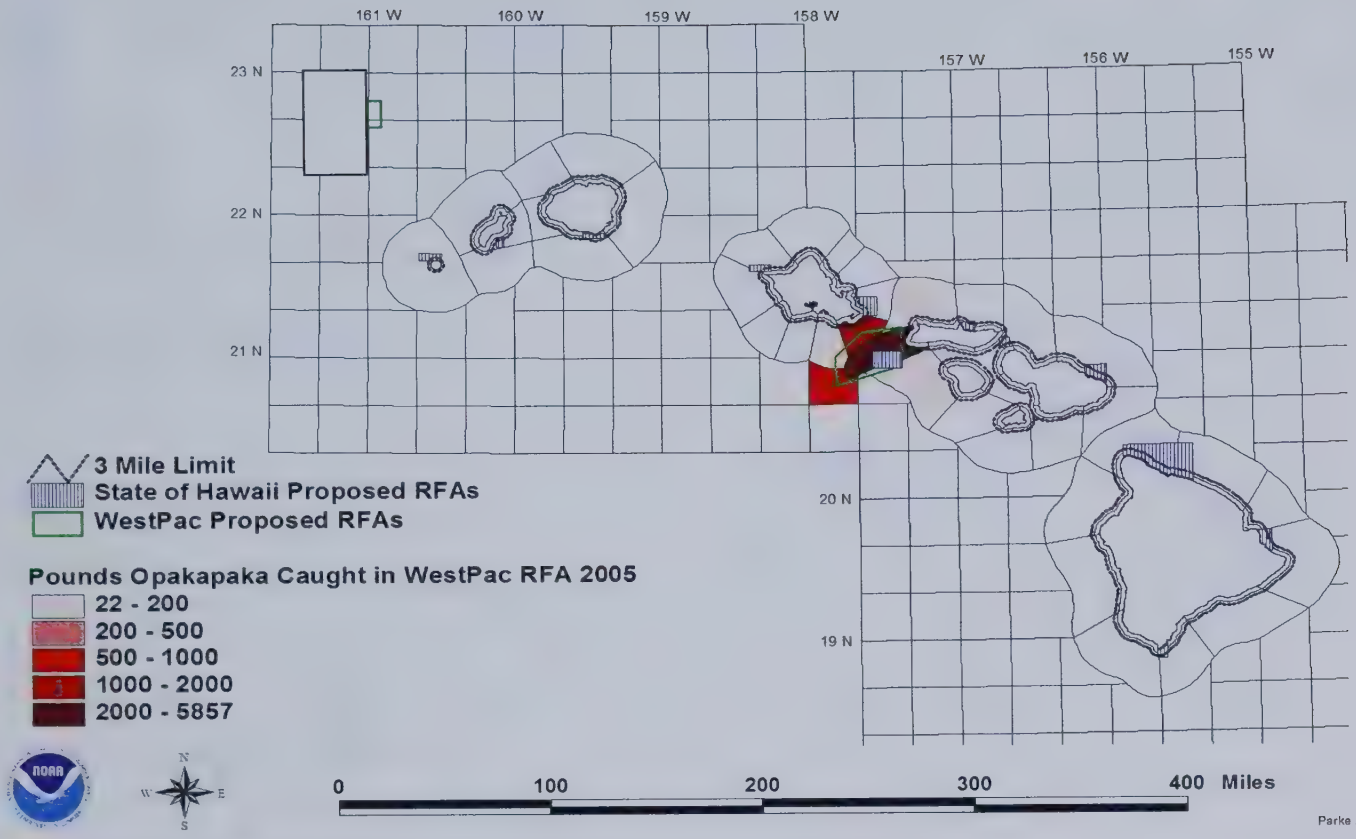

Figure 18. Map of 2005 opakapaka catch in WPFMC RFAs, by reporting area.

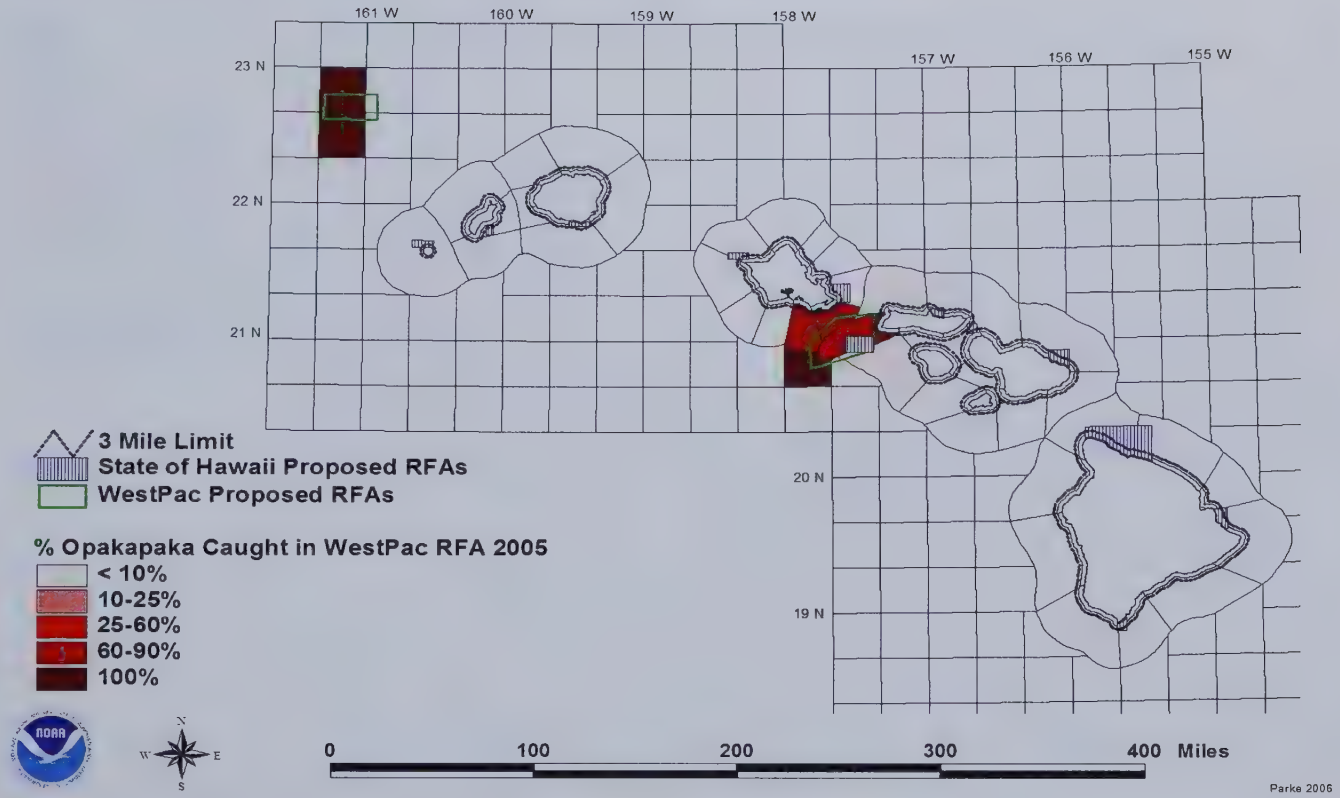

Figure 19. Map of percent 2005 opakapaka catch in WPFMC RFAs, by reporting zone.

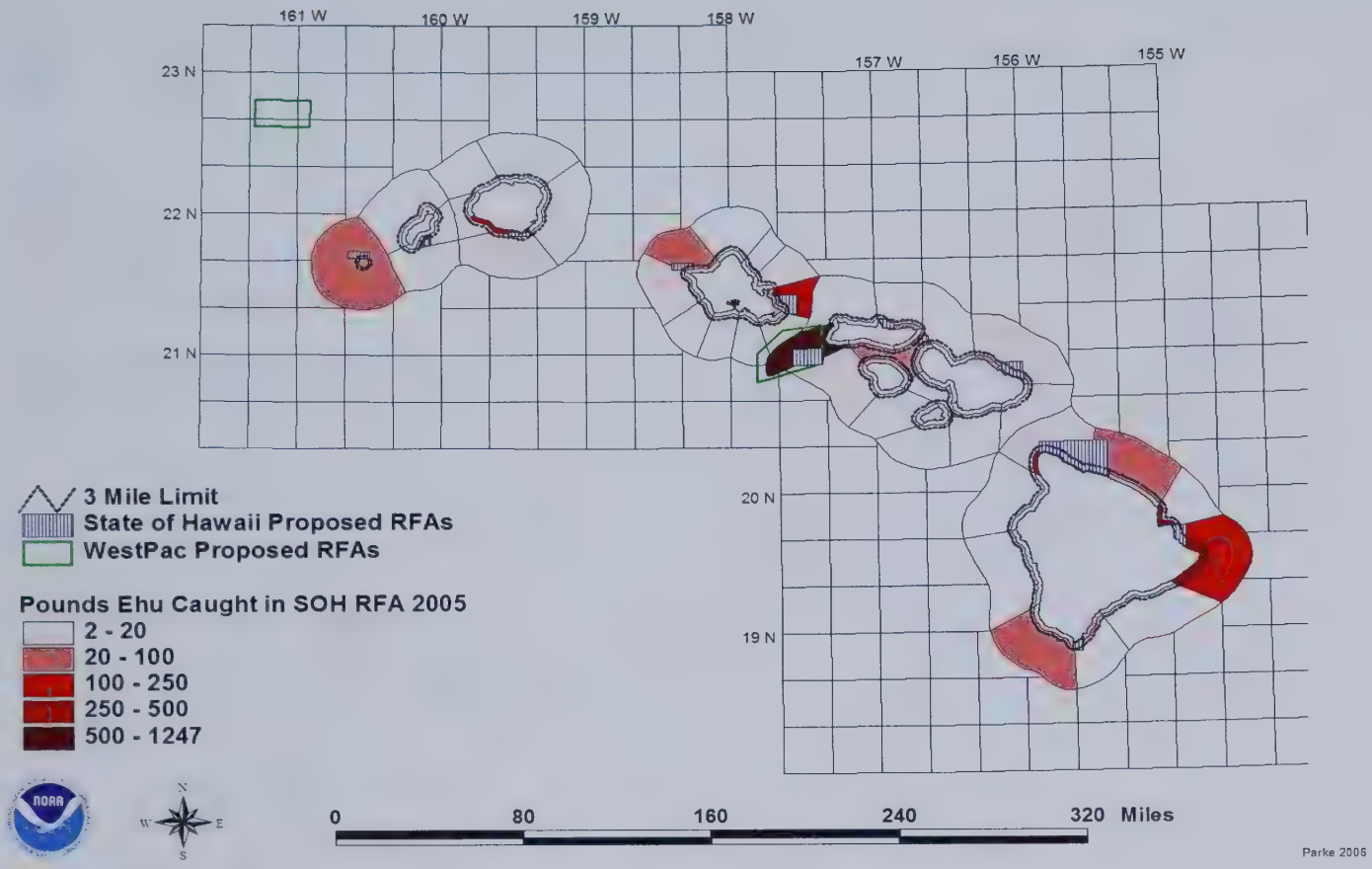

Figure 20. Map of 2005 ehu catch in State of Hawaii RFAs, by reporting zone.

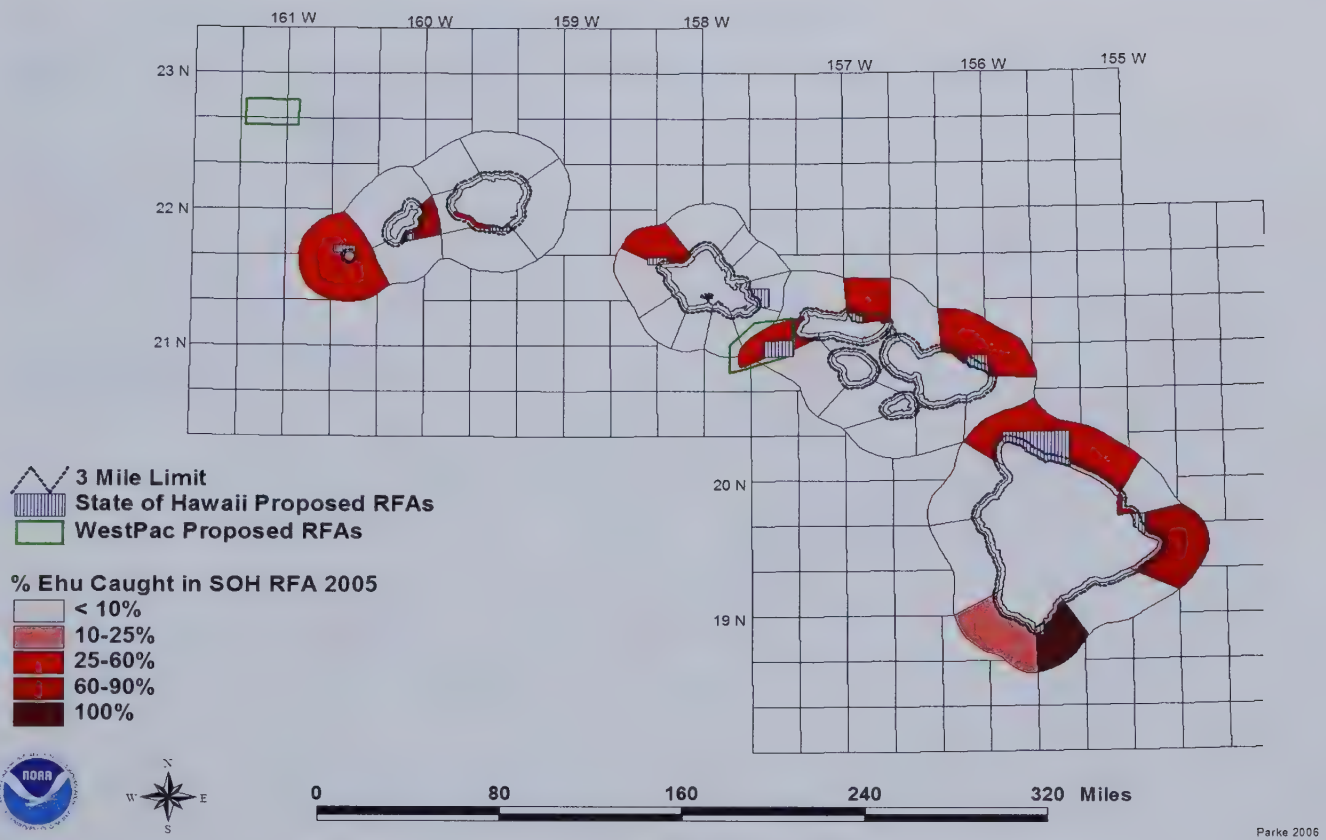

Figure 21. Map of percent 2005 ehu catch in State of Hawaii RFAs, by reporting zone.

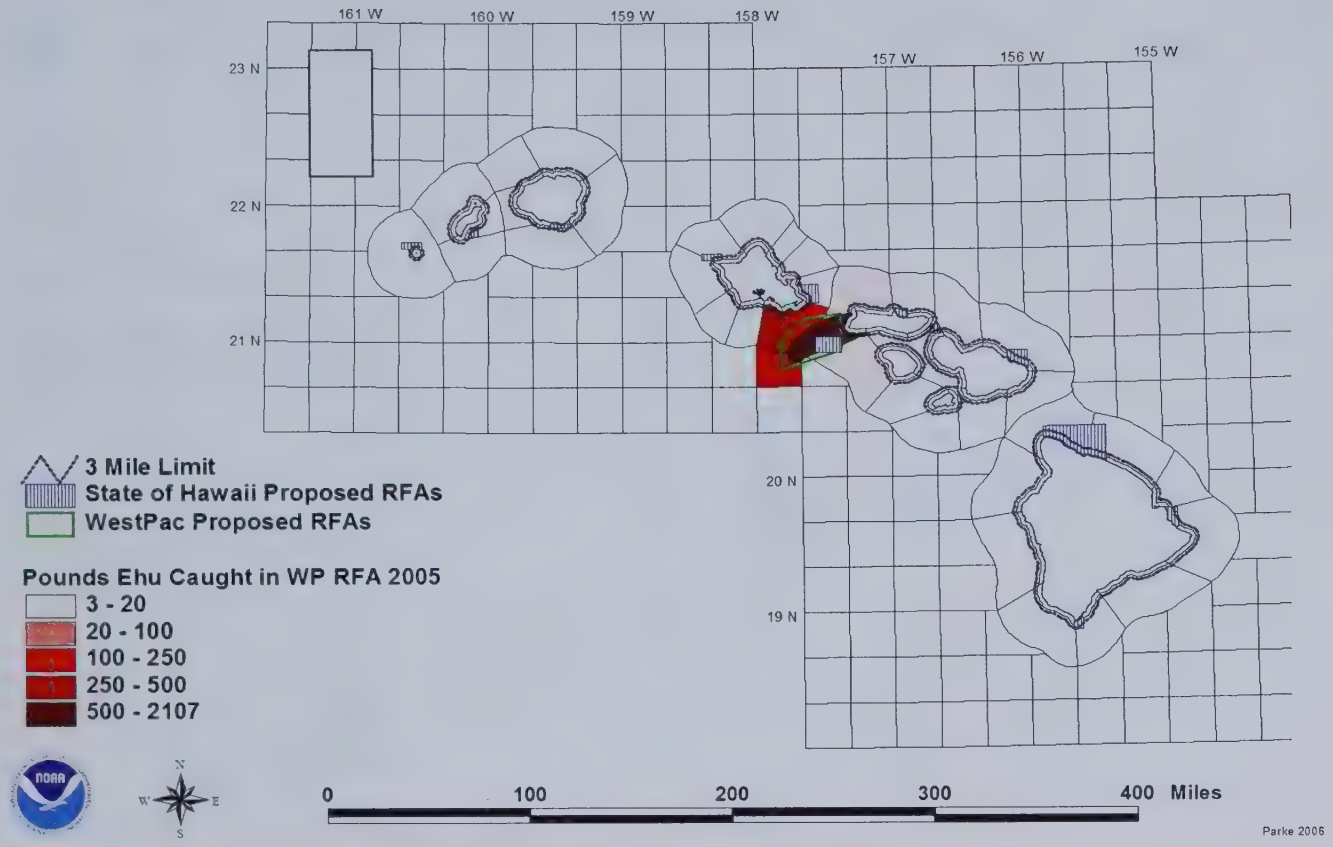

Figure 22. Map of 2005 ehu catch in WPFMC RFAs, by reporting zone.

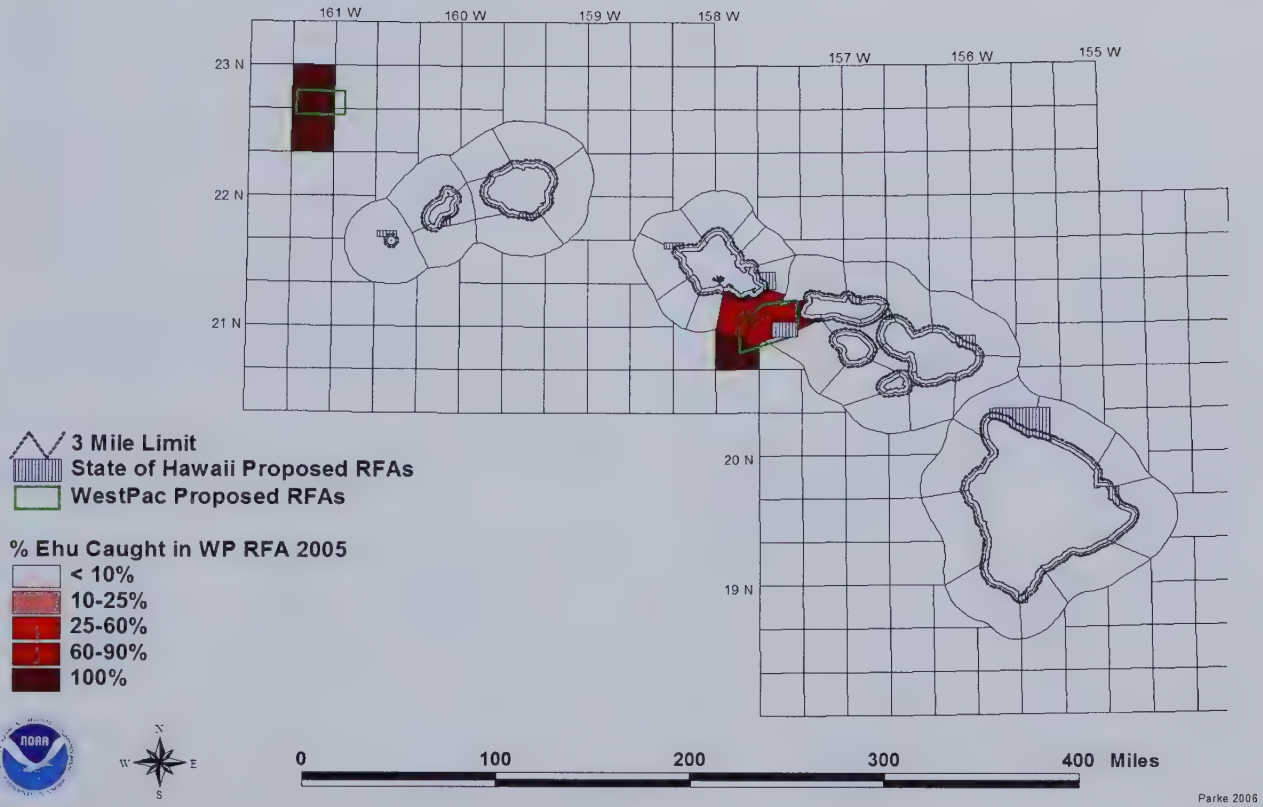

Figure 23. Map of percent 2005 ehu catch in WPFMC RFAs, by reporting zone.

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